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OPERATIONS AND MAINTENANCE MANUAL

ATMOSPHERIC CONTAMINANT SENSOR

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OPERATIONS AND MAINTENANCE MANUAL
ATMOSPHERIC CONTAMINANT SENSOR

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1. SYSTEM DESCRIPTION

The Atmospheric Contaminant Sensor (ACS) (Figures 1-1 and 1-2) is a mass spectrometer system which continuously monitors the atmospheric constituents hydrogen, water vapor, nitrogen, oxygen, and carbon dioxide and in addition the Freons, F11 or F114 and F12 on a demand sampling basis. A functional block diagram of the system is shown in Figure 1-3.

1.1 THEORY OF OPERATION

A brief description of the system is given below in order to provide an overall familiarization with the instrument. The sample to be monitored enters the sample select valve when the sample shutoff valves are opened. The sample passes through a dual filter system and then through the heated inlet leak valve assembly. The sample continues through a flow meter, a flow control valve, another dual filter assembly, a shutoff valve, and finally to the sample transport pump where it is exhausted to the local atmosphere. An extremely small portion of this sample is admitted to the mass spectrometer (called the analyzer) through the heated leak valve assembly. This gas passes into the ion source where it is ionized and the resulting charged particles are electrostatically accelerated and then resolved by the shaped magnetic field of the analyzer magnet to form separate beams of ion current according to the mass of the ions. The separate ion currents strike individual collectors located at precise positions for the masses of interest. This instrument is set up to continuously monitor hydrogen at mass 2, water vapor at mass 18, nitrogen at mass 28, oxygen at mass 32, and carbon dioxide at mass 44. The two pairs of Freons, F11/F12 or F12/F114, can be selected for measurement by a mode selection switch. The Freons F12, F11, and F114 are measured at masses 85, 101, and 135 respectively. Cross interferences and zero drift are automatically corrected by a sequence initiated by the "update" button. The contribution of mass 135 is measured at the mass 101 ion current collector during this update sequence by shifting the ion accelerating voltage. The ion current is converted to electron current at the leads attached to the collectors. These leads pass through single-pin feedthroughs to electrometer amplifiers. The amplifiers amplify the currents, which are in the range of 10^{-14} to 10^{-10} amperes, to provide full-scale output voltages in the order of +10 volts. The output signals are conditioned by a ratioing network and then displayed digitally in torr (mm of Hg) and millitorr (0.001 mm of Hg or 1 micron).

1.2 SYSTEM FEATURES

This instrument has several features that contribute to its efficiency and ease of operation. One is the direct readout of partial pressures in torr. This is accomplished by a summing circuit which controls the overall gain of each

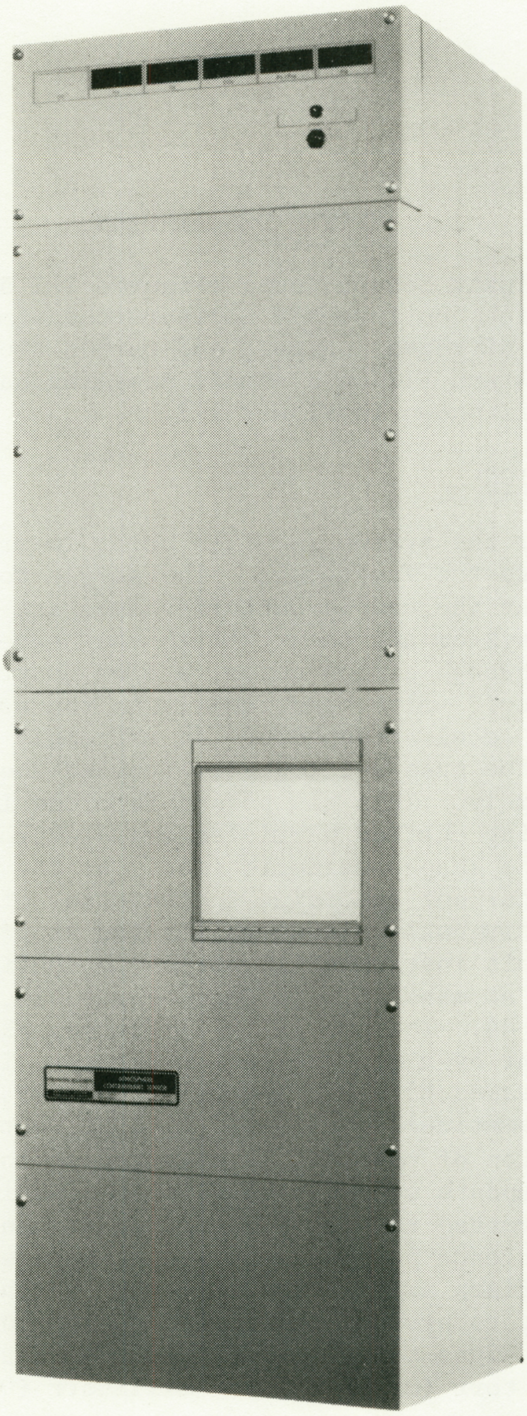

FIGURE 1-1
Atmospheric Contaminant Sensor

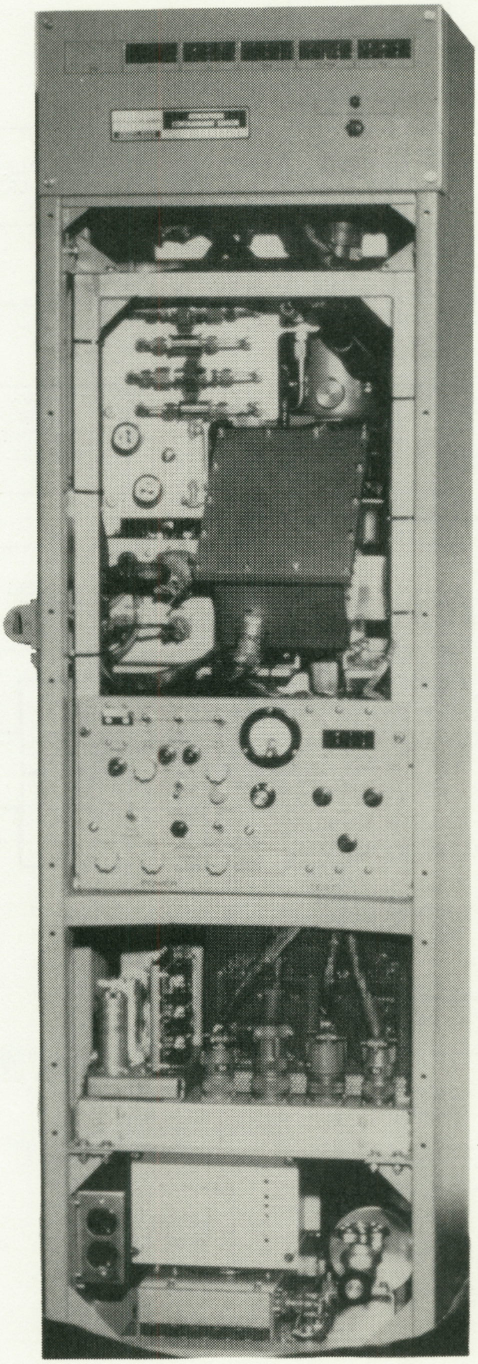

FIGURE 1-2
Atmospheric Contaminant Sensor (With Panel Covers Removed)

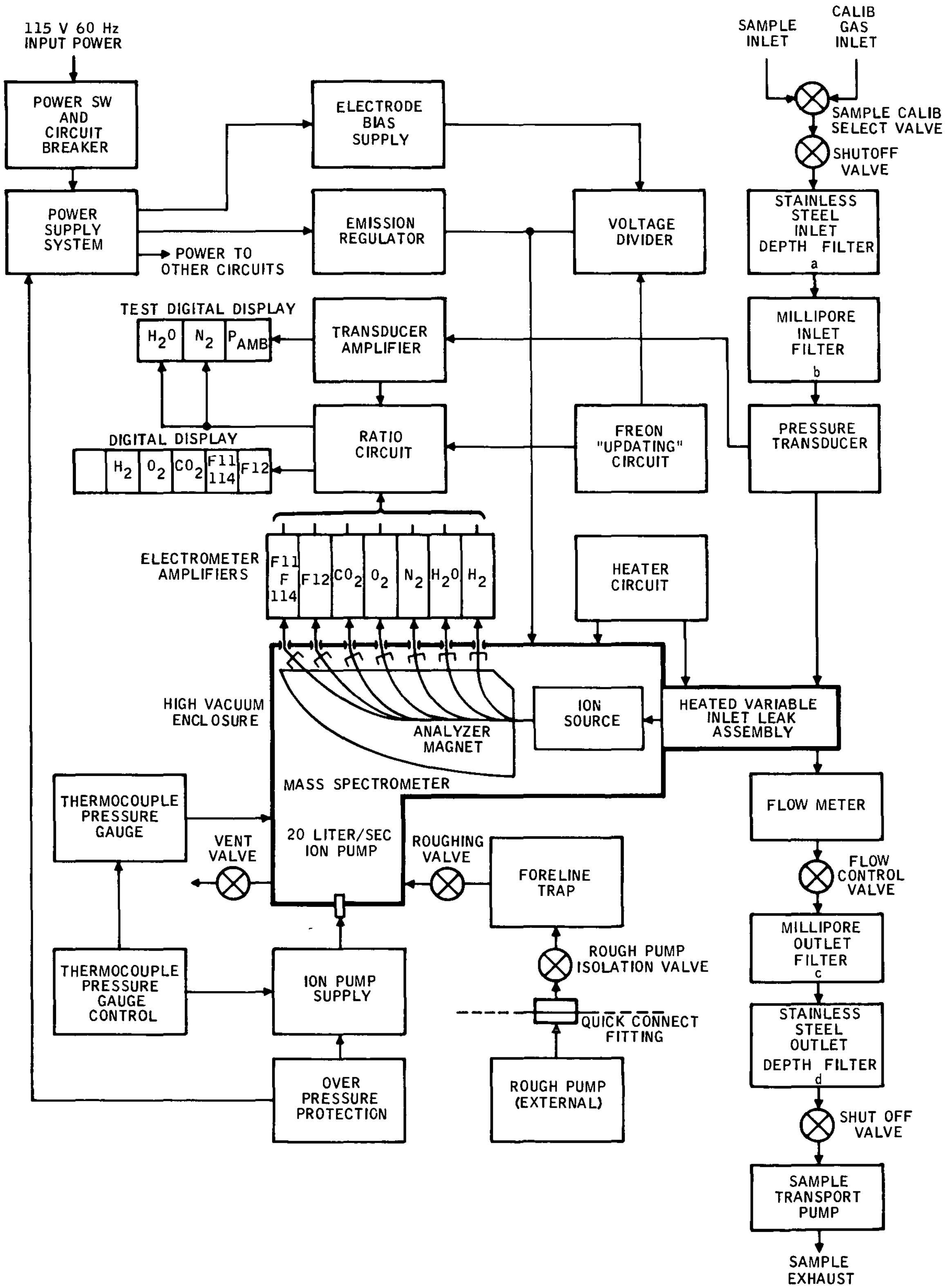

FIGURE 1-3
Atmospheric Contaminant Sensor Block Diagram

channel and forces the sum of the gas partial pressures to equal the ambient atmospheric pressure as read by a pressure transducer. The signals representing the partial pressures are analog voltages and must be converted to digital pulses to operate the displays. This is accomplished by one analog-to-digital converter which drives all the displays. A multiplexer circuit sequentially switches each of the incoming analog signals to the A/D converter and simultaneously enables the appropriate display channel. Freon 114, if present, interferes with the detection of Freon 12 as described above. The Freon correction circuits compensate for this and with the Freon sequencing circuit also compensate for any drift in the Freon channel electrometers. All this occurs before the signals reach the multiplexer described above.

Other electronic subsystem components include the power supplies, power sequencing circuits, and control circuits. The analyzer power supply (located in the card rack module) contains the regulated supplies for all the electron and ion accelerating and focusing elements and also contains the emission regulator. The support module contains the ion pump power supply, the low voltage power supply and the power control card rack. The temperature control boards for the valve and source heaters, the relay board and the vacuum control board are located on the power control card rack.

In addition to the inlet system, analyzer, and electronics subsystem described above, there is a vacuum support system. A 20 liter/second ion pump provides the primary vacuum required for the operation of the mass spectrometer. It is an integral part of the analyzer housing which also includes the thermocouple gauge, and the roughing line plumbing. The ion pump is operated by a 5 kV power supply, and is protected by the output of the thermocouple gauge control so that it can only turn on when the pressure is below a preset level. The ion pump current, which indicates the internal pressure, is sensed by an overpressure protection circuit which completely inhibits the mass spectrometer electronics unless the ion pump current is less than 5 mA. When the ion pump current is between 5 and 1 mA the mass spectrometer electronics are only partially inhibited, that is, the filament is in a partially on condition (approximately when the ion pump current is 1/2 power) and the source heater and inlet heater circuits are operational. When the ion pump current is below 1 mA the mass spectrometer electronics are fully operational.

When the pressure is above the point at which the ion pump can turn on, it is necessary to rough down the system through the roughing valve. This is accomplished by an external mechanical rough pump which is filtered by an internal molecular sieve trap to prevent backstreaming oil vapors from contaminating the analyzer and ion pump.

1.3 DESCRIPTION OF CONTROLS AND MONITORS

The atmospheric contaminant sensor is housed in five modules:

a. Card Rack Module: Contains analog signal processing electronics and analyzer power supplies.

b. Display Module: Contains the main displays and the associated digital signal processing electronics.

c. Analyzer Module: Contains Mass Spectrometer Analyzer, Control and Test Display Panel.

d. Support Module: Contains power supplies and power sequencing electronics.

e. System Enclosure: Houses the four modules listed above in addition to the fan, filter, EMI filter, auxiliary ac outlet and molecular sieve trap subsystem.

Figures 1-4 through 1-8 identify all system controls which will be discussed in this manual.

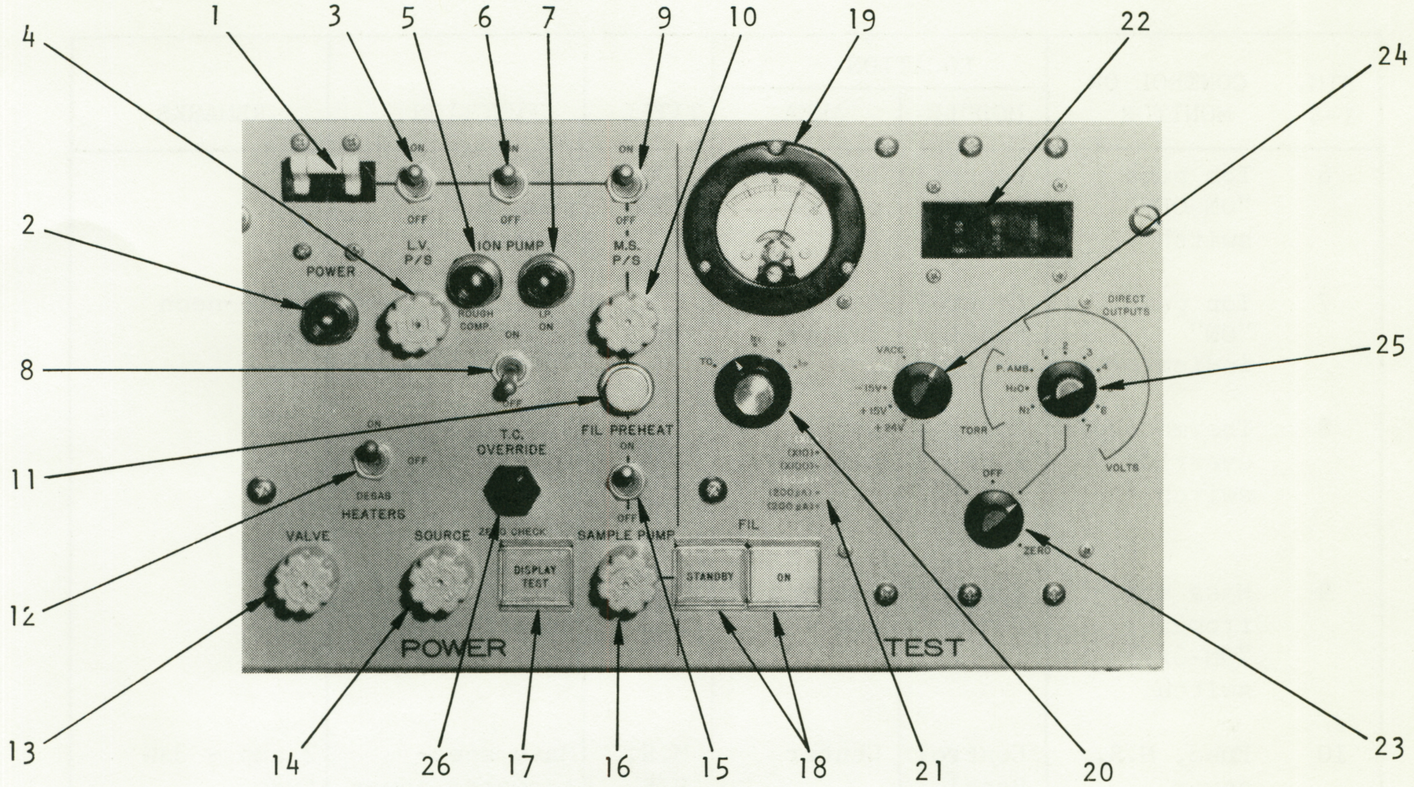

FIGURE 1-4
Control Panel

Controls and Monitors

FIG. 1-4	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
1	System circuit breaker	Control Panel	Upper left	POWER	Primary system protection	20 amp rating
2	Power on indicator lamp	Control Panel	Upper left	POWER	Indicates when circuit breaker is on	NE51H-neon lamp
3	Low voltage power supply "ON-OFF" switch	Control Panel	Upper left	L.V. P/S	Turns on low voltage power supply	
4	Fuse, low voltage power supply	Control Panel	Upper left	L.V. P/S	Protection of L.V. P/S	2 amp - 3AG fuse
5	Roughing operation completion indicator	Control Panel	Left, upper center	ROUGH COMP.	Indicates that system has been roughed down to 10 microns when lit	NE51H- neon lamp

FIG. 1-4	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
6	Ion pump "ON-OFF" switch	Control Panel	Left, top center	ION PUMP	turns on ion pump H.V. supply	
7	Ion pump "ON" indicator	Control Panel	Left, upper center	I.P. ON	Indicates that ion pump is "ON" or "OFF"	NE51H-neon lamp
8	Thermocouple override switch	Control Panel	Left, center	T.C. OVER-RIDE	By-passes thermocouple pump protection circuit	
9	Mass spectrometer "ON-OFF" switch	Control Panel	Center, top	M.S. P/S	Turns on mass spectrometer power supply	
10	Fuse, M.S. power supply	Control Panel	Center	M.S. P/S	Mass spectrometer power supply protection	2 amp - 3AG fuse
11	Filament pre-heat indicator	Control Panel	Center	FIL PRE-HEAT	Indicates heating current is applied to filament when lit	28 V lamp
12	Degas "ON-OFF" switch	Control Panel	Far left, center	HEATERS	Heating mode selection	Switch, three position center "OFF"
13	Fuse, valve heater	Control Panel	Left, bottom	VALVE	Protects 24 V power supply	2 amp *
14	Fuse, source heater	Control Panel	Left, center bottom	SOURCE	Protects 24 V power supply	2 amp *
15	Sample pump "ON-OFF" switch	Control Panel	Lower, center	SAMPLE PUMP	Activates sample pump	
16	Fuse, sample pump	Control Panel	Lower, center	SAMPLE PUMP	Protects system sample pump	3 amp - slow blow

*In order for heaters to operate both fuses must be operational.

FIG. 1-4	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
17	Display test switch	Control Panel	Lower, left	DISPLAY TEST	Test L.E.D. display elements	When actuated displays read 1888
18	Filament "ON" and "STANDBY" switch	Control Panel	Lower center	FIL	Operating mode selection of filament	Turns analyzer "ON" or returns analyzer to "STANDBY"
19	Analog test meter	Control Panel	Center, top		Monitor TC, I_{AN}, I_{EA}, I_{IP}, I_{IP}	Meter 0-20 μA
20	Test point selector switch	Control Panel	Center		Selects test points to be monitored by "Analog Test Meter"	The test points are as follows: TC - Thermocouple pressure gauge I_{AN}- Anode current I_{EA}- Electron Accel-lerator current I_{IP}- Ion pump current (200 μA) I_{IP}- Ion pump current (200 mA)
21	Scaling legend	Control Panel	Right, left center		To indicate the full scale or scaling factor for the analog and digital monitors	Numbers are color coded to match "test point selector switch" positions
22	Digital test meter	Control Panel	Right, upper		To monitor selected functions on items 23, 24, 25	
23	Monitor selector switch	Control Panel	Right, lower		Selection of either power switch or out-put monitor switch	Item 24, power supply monitor switch. Item 25, output monitor switch

FIG. 1-4	CONTROL OR MONITOR	LOCATION MODULE	AREA	TITLE	FUNCTION	REMARKS
24	Power supply monitor	Control Panel	Right, center		Selection of system power supply moni- toring points	+24 - Unregulated power supply +15 - Regulated power supply -15 - Regulated power supply +5 - Regulated power supply VACC - Ion accel- erating voltage TV - Valve Tempera- ture control- ler drive TS - Source Tem- perature controller drive *Ratioed 10 V output
25	Output monitoring switch	Control Panel	Right, far center		Selection of system elec- tronics output	N_2 - Nitrogen out- put (torr) H_2O - Water vapor output (torr) P.AMB - Sample pres- sure (torr) 1 - Hydrogen elec- trometer output (volts) 2 - Water vapor electrometer output (volts) 3 - Nitrogen elec- trometer out- put (volts) 4 - Oxygen elec- trometer out- put (volts) 5 - Carbon dioxide electrometer output (volts) 6 - Freon 12 electrometer output (volts) 7 - Freon 11/114 electrometer output (volts)
26	Electrometer and output zero check	Control Panel	Left, center	ZERO CHECK	Deflects ion beams to allow measurement of zero levels	

*Ref. 10 V. Zeros read on positions 1-7 of Item 22 with switches 23 and 25 properly set. set.

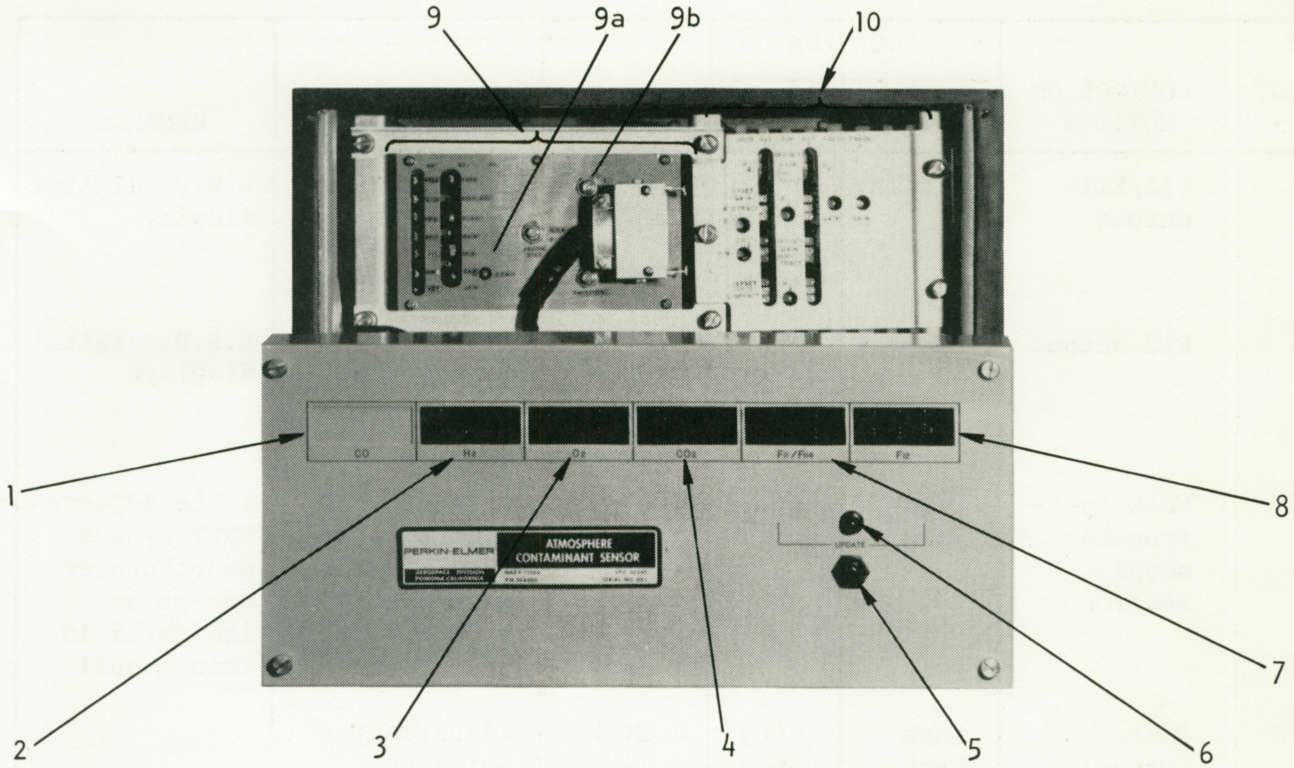

FIGURE 1-5
Digital Display and Card Rack Modules

FIG. 1-5	CONTROL OR MONITOR	LOCATION MODULE	AREA	TITLE	FUNCTION	REMARKS
1	CO output	Display	Left	CO	Not used in current system design	
2	H_2 output	Display	Left, center	H_2	Display quantity of H_2 in torr	L.E.D. digital displays
3	O_2 output	Display	Center	O_2	Display quantity of O_2 in torr	L.E.D. digital displays
4	CO_2 output	Display	Center	CO_2	Display quantity of CO_2 in torr	L.E.D. digital displays
5	Freon updating control switch	Display	Right, lower	UPDATE	Initiate Freon updating logic	Operator demand
6	Update operation indicator	Display	Right, lower	UPDATE	Indicates updating operation in process	Freon update complete when light goes out

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FIG. 1-5	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
7	F11/F114 output	Display	Right, center	F11/F114	Display Freon 11, Freon 114 or in milli-torr	L.E.D. digital display
8	F12 output	Display	Right, center	F12	Display quantity of Freon 12 millitorr	L.E.D. digital displays
9	Mass Spec-trometer supply section	Card Rack	Left, upper		Generate and control proper voltages for mass spec-trometer operation	To be adjusted ONLY by the manufacturer except as indicated in this manual
9a	Emission current	Card Rack	Left, upper	I EMIS	Adjustment of emission current	
9b	Filament selector switch	Card Rack	Top, center	FIL	Selection of one of two filaments for operation	
10	Signal processing electronics	Card Rack	Top, right		Process all raw mass spectrometer data to be displayed	To be adjusted ONLY by the manufacturer

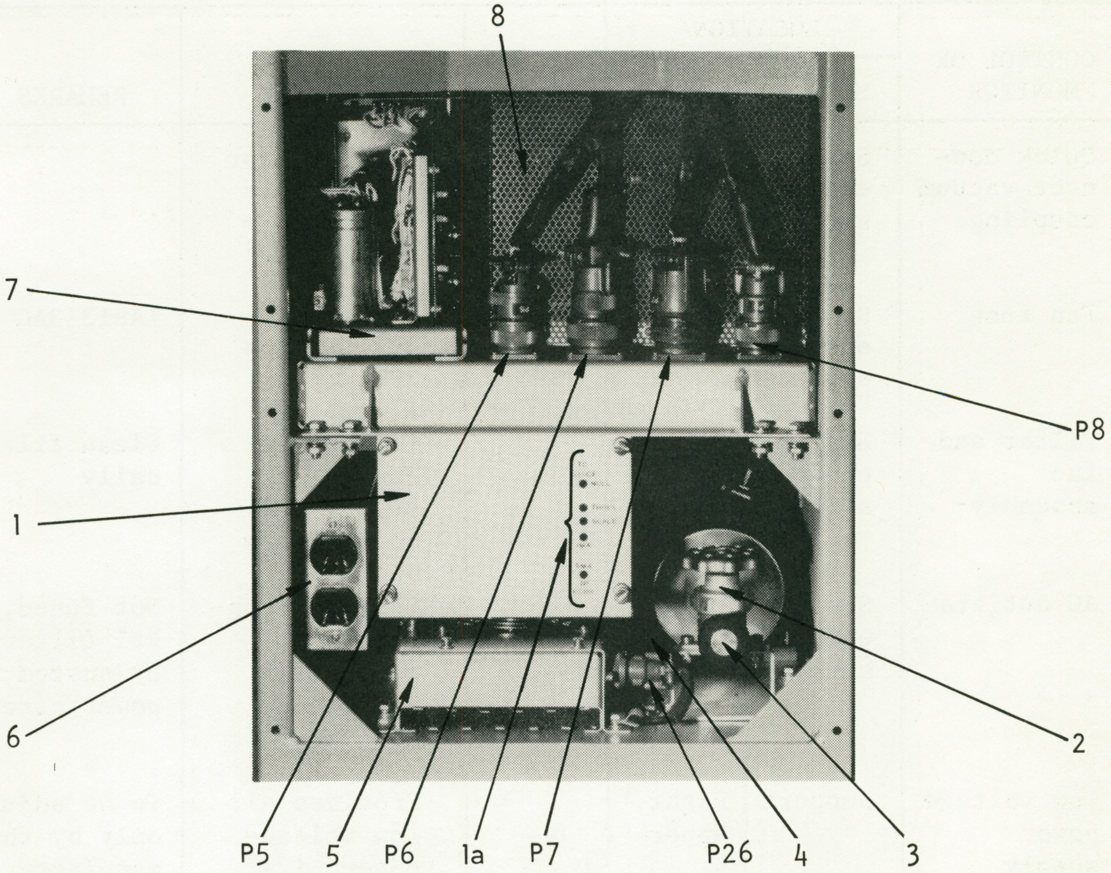


FIGURE 1-6
Support Module, Roughing Filter and Fan Filter Assembly

FIG. 1-6	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MOUDLE	AREA			
1	Heaters & power control protection circuits	Support	Lower, left		Houses circuit cards	
1a	Thermocouple and vacuum protect adjusts	Support	Lower, center	TC gauge Null Thresh Scale 1 mA 5 mA IP Curr	Allow setting of operating parameters of enclosed circuits	To be adjusted ONLY by the manufacturer
2	Rough pump isolation valve	System enclosure	Lower, left		Isolates rough pump filter from ambient	Keep rough pump filter contamination free and evacuated

FIG. 1-6	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
3	Quick con- nect vacuum coupling	System enclo- sure	Lower, left		Coupling for attaching external rough pump	
4	Fan fuse	System enclo- sure	Lower, left		Protects system fans	1AS13-3AG
5	Filter and fan assembly	System enclo- sure	Lower, right		Filters in- coming air supply and houses fans	Clean filter daily
6	AC outlets	System enclo- sure	Lower, right		Provides con- venience outlet for service equipment	Not fused, or RFI filtered by sustem power circuit
7	Low voltage power supply	Support	Right, upper		Provides all low voltage power, i.e., $\pm$15 V, +5 V, $\pm$24 V	To be adjusted only by the manufacturer
8	Ion pump power supply	Support	Left, upper		Provides power for ion pump	CAUTION: This is a 5 kV power supply capable of delivering 150 mA

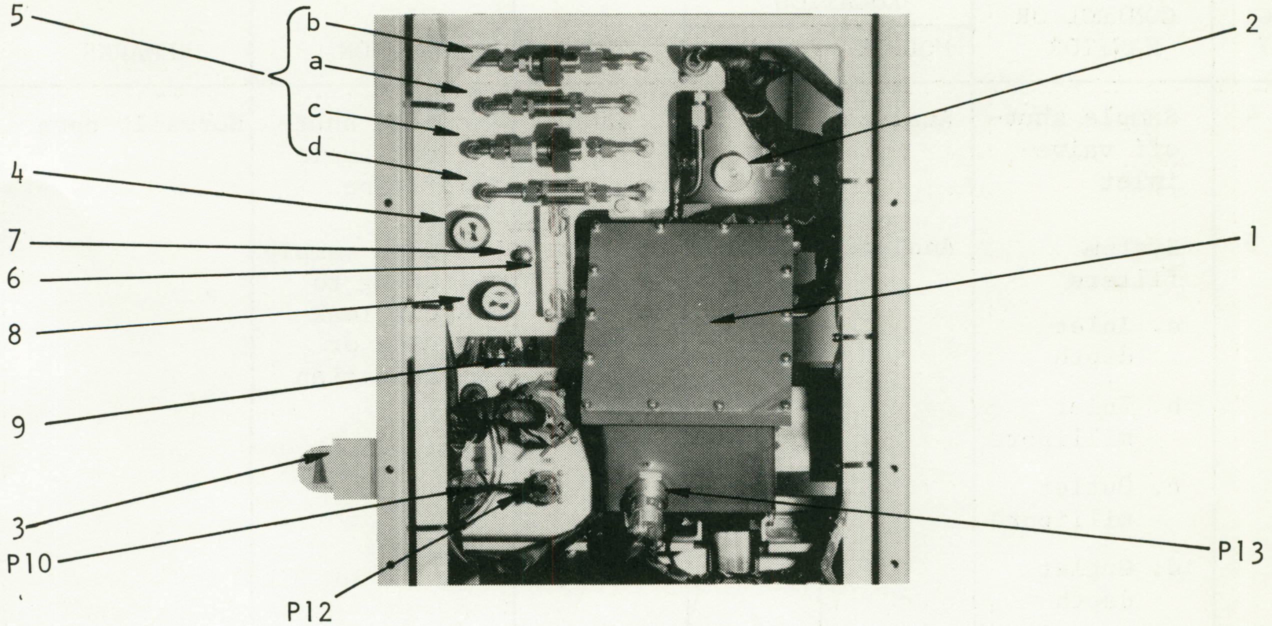


FIGURE 1-7
Analyzer Module

FIG. 1-7	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
1	Electrometer amplifier enclosure	Analyzer	Center		Houses electrometer amplifiers and provides electrostatic shielding as well as hermetic seal	Contains 7 amplifier boards and dessicant bays. Change dessicant bays if opened for service.
2	Heated inlet leak valve	Analyzer	Center		Provides adjustable molecular leak of sample to ion source	CAUTION: Setting and adjustment are very critical. Do not disturb unless absolutely necessary.
3	Sample Selector Valve	Analyzer	Center, left		Selects calibration gas or sample	

FIG. 1-7	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
4	Sample shut-off valve-inlet	Analyzer	Upper, left	SAMPLE IN	Provides shut-off of sample inlet line	Normally open
5	System filters a. Inlet depth b. Inlet millipore c. Outlet millipore d. Outlet depth	Analyzer	Upper, left		Provides sample filtering to prevent leak plugging or contamination	
6	Flowmeter	Analyzer	Upper, left		Provides measurement of inlet sample flow rate.	Normally 0.04 SCFH
7	Flow control needle valve	Analyzer	Upper, left	FLOW CONTROL	Provides adjustment of sample flow rate	
8	Sample shut-off valve outlet	Analyzer	Upper, left	SAMPLE OUT	Provides shut-off of sample outlet line	Normally open
9	Sample transport pump	Analyzer	Center, left, rear		Provides vacuum source for sample transportation from remote locations	Stainless steel metal bellows type pump. No service needed.

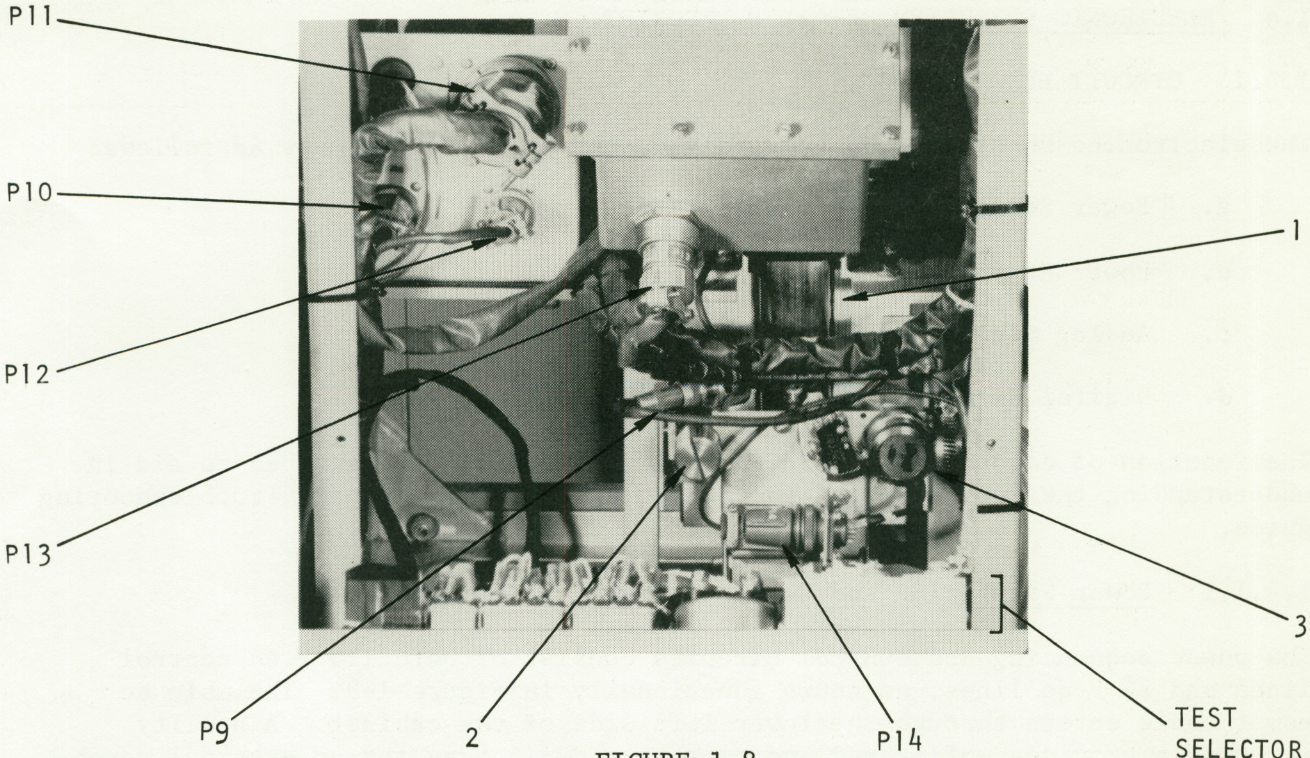


FIGURE 1-8
View Behind Control Panel

FIG. 1-8	CONTROL OR MONITOR	LOCATION		TITLE	FUNCTION	REMARKS
		MODULE	AREA			
1	Analyzer housing	Analyzer	Center		Provide enclosure for all vacuum components	
2	Vent valve	Analyzer	Center		Provide inlet for venting vacuum housing for service	Normally closed. USE EXTREME CAUTION, this is a stainless steel seat valve.
3	Roughing valve	Analyzer	Center		Provides exhaust port for roughing vacuum housing	Cam division provides protection for ion pump. Power line is opened when valve is open. Normally closed. USE EXTREME CAUTION, this is a stainless steel seat valve.

1.4 ELECTRONIC SUBSYSTEM DETAILED DESCRIPTION

1.4.1 CIRCUIT DESCRIPTION

The electronics subsystem may be subdivided into four (4) groups as follows:

a. Power Sequencing and Control Circuits

b. Power Supplies

c. Analog Signal Processing Circuits

d. Digital Signal Processing Circuits

The function of each circuit within these groups will be described to aid in understanding the operation of the system and to introduce the troubleshooting guide.

1.4.1.1 Power Sequencing and Control Circuits

The power sequencing and control circuits consist of both 115 V ac control lines and 24 V dc lines, as shown functionally in Figure 1-9. The main ac power cable enters through the lower left side of the cabinet. A utility receptacle provides unfiltered and unprotected 115 V ac for an external roughing pump and for test or calibration equipment (see Figure 1-10). The line voltage is filtered and then protected by a 20 A circuit breaker on the control panel. The fans and main power light are activated by the circuit breaker and 115 V ac is delivered to the sample pump switch, the low voltage power supply switch and the ion pump power supply switch.

Table 1-1 shows the conditions necessary to turn on the different portions of the instrument and can be used as an aid in understanding the function of each of the front panel switches and the power control relays.

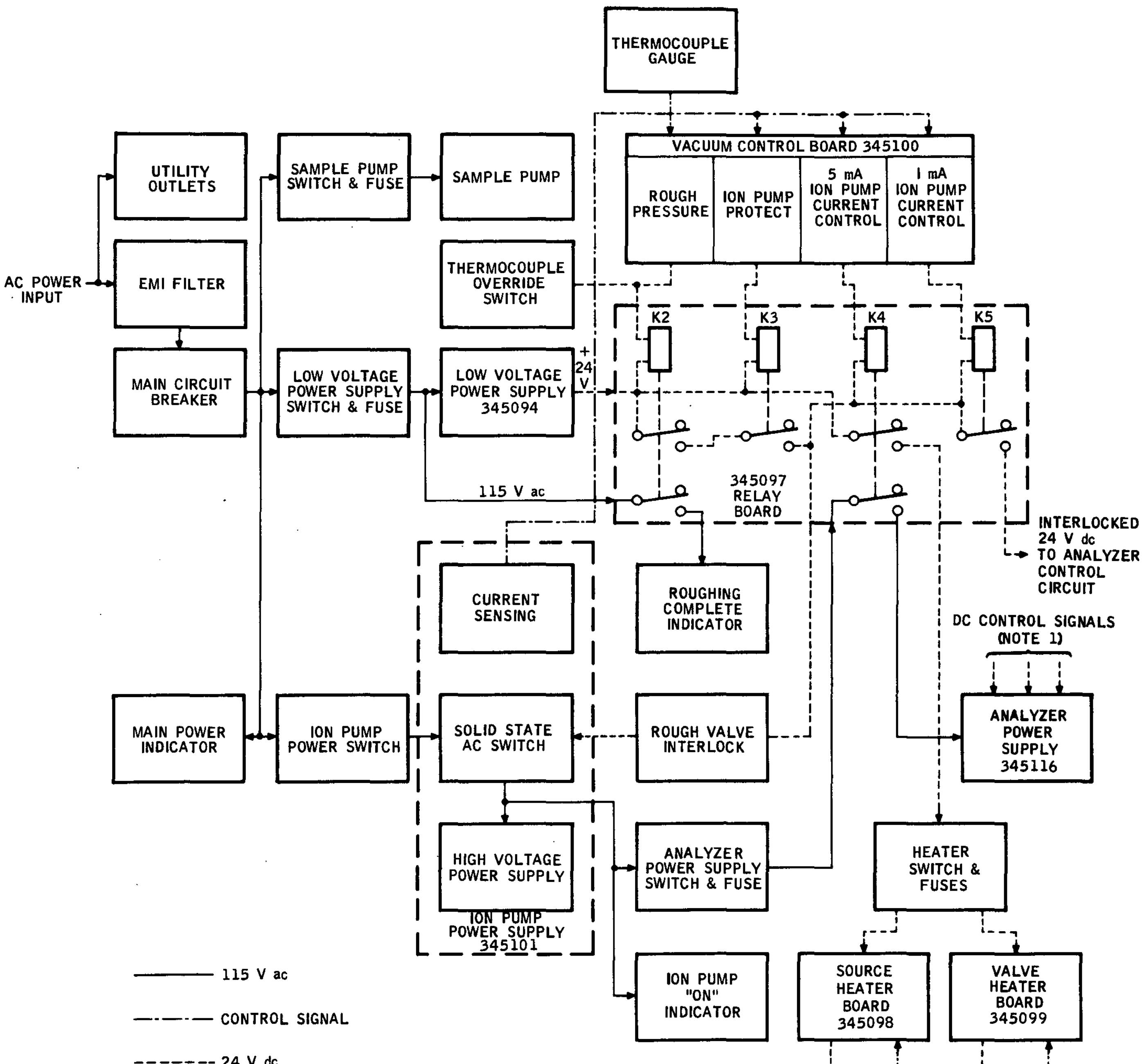
The low voltage power supply may now be turned on. Further power turn on is controlled by the vacuum control board and the relay board. The vacuum control board has four functions:

a. Closes relay K2 when analyzer pressure is below 10 microns. The pressure is sensed using a thermocouple within the analyzer vacuum.

b. Opens relay K3 when a long-term ion pump overload is sensed.

c. Closes relay K4 when the ion pump current is less than 5 mA. The source and valve heaters may then be turned on. The analyzer power supply may be turned on.

d. Closes relay K5 when ion pump current is less than 1 mA. Allows analyzer filament to be turned full on.



NOTES:

DC CONTROL SIGNALS ARE PROVIDED TO THE ANALYZER POWER SUPPLY BY THE ANALYZER CONTROL CIRCUIT. THESE SIGNALS ARE:

1. FILAMENT PREHEAT
2. Z-AXIS SHORTING (USED FOR AMPLIFIER ZEROING)
3. SCAN (CHANGES ION ACCELERATOR FOR FREON 114 DETECTION)

FIGURE 1-9
Power Control Circuit Functional Diagram

TABLE 1-1

Power Turn On Chart

CONDITION

CONTROLS	USE CONVENIENCE OUTLETS	FANS ON	SAMPLE PUMP ON	LOW VOLTAGE POWER SUPPLY ON	ION PUMP ON	HEATERS ON	ANALYZER POWER SUPPLY ON	ANALYZER ON
MAIN CIRCUIT BREAKER		X	X	X	X	X	X	X
SAMPLE PUMP SWITCH			X					
LOW VOLTAGE POWER SUPPLY SWITCH				X	X	X	X	X
ION PUMP POWER SUPPLY SWITCH					X	X	X	X
ROUGH VALVE INTERLOCK					X	X	X	X
HEATER SWITCH						X		
ANALYZER POWER SUPPLY SWITCH							X	X
FILAMENT "ON"								X
K2 (ROUGHING COMPLETE)					X	X	X	X
K3 (PUMP PROTECT)					X	X	X	X
K4 (5 mA ION PUMP CURR)						X	X	X
K5 (1 mA ION PUMP CURR)								X
K1 (ANALYZER "ON")								X

X SWITCH ON OR RELAY CLOSED

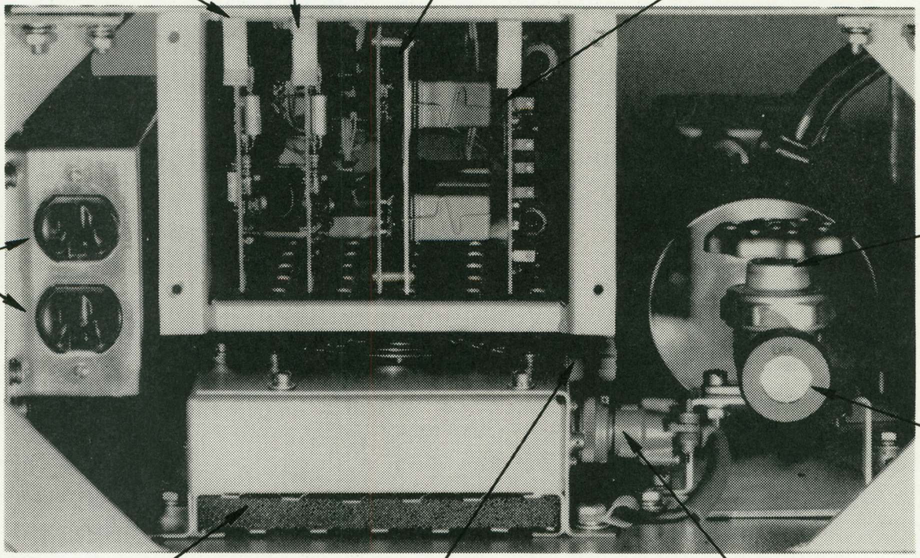


FIGURE 1-10
Lower Cabinet Area

The pressure within the analyzer must be less than 10 microns before the ion pump is actuated to prevent damage to the ion pump. Relay K2 closes when the pressure falls below 10 microns and applies 24 V dc through K3 and the rough valve interlock to the solid state switch, which controls the 115 V ac in the ion pump. The thermocouple override switch closes K2 regardless of the pressure within the analyzer. K3 remains closed unless long-term ion pump overlaod is sensed. The ion pump power supply is current limited at 150 mA and a direct short for about six minutes will cause K3 to open. Lower ion pump currents will be tolerated for proportionately longer times. After K3 is opened it will recycle closed after about six minutes and the ion pump will again be turned on. An ion pump current of 16 mA or less will be tolerated for an indefinite length of time. The "roughing complete" panel lamp is lit when K2 is closed.

The ion pump current decreases as the pressure within the analyzer decreases and when the current falls below 5 mA K4 is actuated. This relay applies 117 V ac to the analyzer power supply when the analyzer power supply switch is on and supplies 24 V dc to the heater switch.

When initially turned on the analyzer power supply delivers about half power to the analyzer filament. When the ion pump current falls below 1 mA K5 is actuated. 24 V dc is then supplied to the front panel "ON" switch and allows the filament to be turned full on.

1.4.1.2 Power Supplies

The low voltage power supply is located in the support module and contains the following power supplies:

	Voltage	Current Rating	Regulation	Supplies Voltage to:
a.	5 V dc	4.5 A	Regulated	Digital logic & digital display
b.	+15 V dc	500 mA	Regulated	Analog and digital signal processing circuits
c.	-15 V dc	500 mA	Regulated	
d.	24 V dc	3 A	Unregulated	Relays, heaters, panel lights

The ion pump power supply (see Figure 1-11) contains monitoring circuits and a 5000 V dc high voltage supply which is current limited at 150 mA. The vacuum control circuits which drive K4 and K5 are fed a "delayed current sense" signal by the ion pump monitor circuit. This signal simulates a high ion pump current when the ion pump power supply is off so that relays K4 and K5 are not activated until the supply is turned on and the ion pump current is actually below the preset levels.

The analyzer power supply (see Figure 1-12) contains:

a. A constant current high voltage power supply and voltage divider network which supplies:

   1. Electron accelerating and focusing voltages

   2. Ion accelerating and focusing voltages

b. An emission regulator which supplies the filament current.

In order to detect F114 on the F11 collector the ion accelerating and focusing voltages are shifted by the scan relay in the analyzer power supply. The relay is actuated automatically by the freon sequencing circuits or manually by a switch on the analyzer power supply. To zero the freon circuits the z-axis relay grounds one of the z-axis plates so that no ions reach the analyzer. At that time the output from the freon electrometers is due to the dc offset only. The zero check button on the control panel may also be used to actuate the z-axis relay when checking the zero on other electrometers.

The emission regulator is designed to control the total electron emission or the anode current of the ion source as selected by the switch on the analyzer power supply. There are two filament and electron focusing systems within the analyzer. A switch on the front of the analyzer power supply selects either filament 1 or filament 2. The filament preheat relay causes the emission regulator to supply about half the normal power to the filament until the "FIL ON" button is pushed. Figure 1-13 shows the functional operation of the analyzer control circuits.

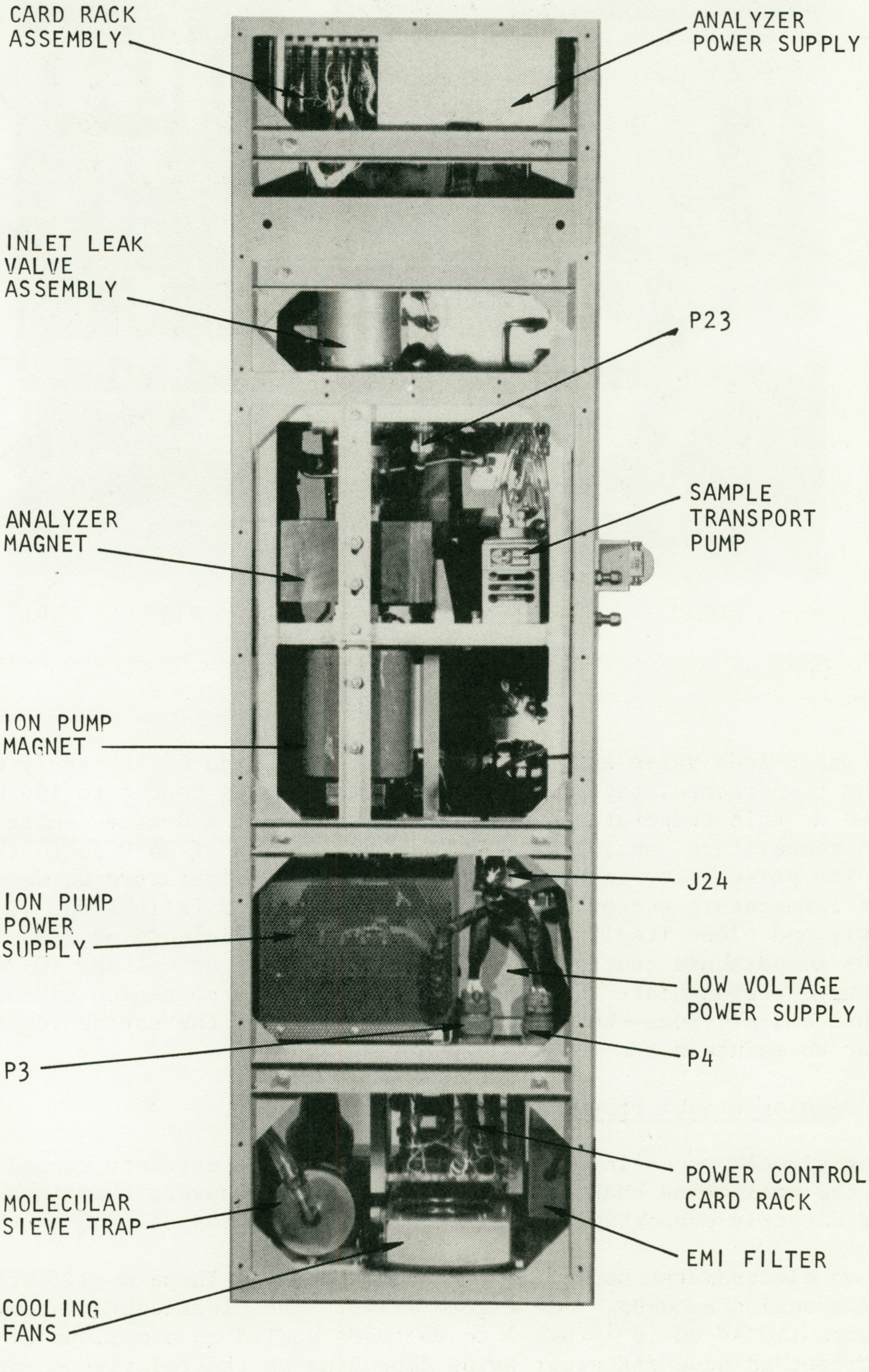


FIGURE 1-11
Atmospheric Contaminant Sensor Rear View

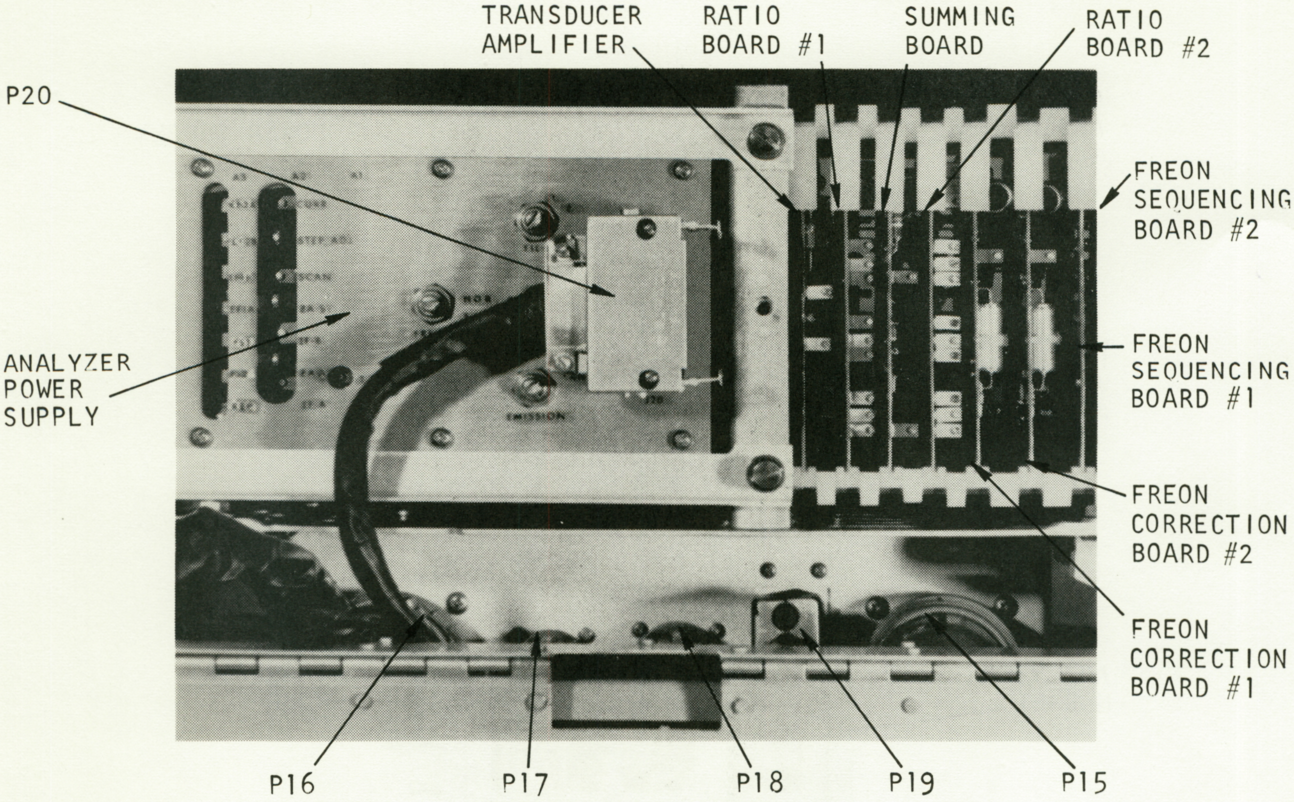


FIGURE 1-12
Card Rack Assembly

Both the inlet leak valve and the ion generating region of the analyzer are heated and temperature stabilized. The inlet valve is heated to 100°C and maintained at this temperature within a few tenths of a degree centigrade by the valve temperature controller. It supplies pulses of 24 V dc to the heater. The pulses vary in width depending on the temperature as sensed by the valve temperature sensor. In the event of a power failure the valve will cool slowly and close itself due to the thermal coefficients of its parts. The source temperature controller supplies a variable dc voltage (0-24 V dc) to the source region heater. A thermistor in the source region senses the temperature and provides the feedback information for the source temperature controller to maintain the temperature at 150°C.

1.4.1.3 Analog Signal Processing Circuits

The analog signal processing circuits take the minute currents caused by ions striking the collection buckets of the analyzer and convert them into voltages which are directly proportional to the partial pressures of each of the gases.

There is an electrometer amplifier for each channel. These amplifiers are housed in a sealed assembly (see Figure 1-14). The electrometers convert the ion currents (10^{-10} to 10^{-14} amps) to voltages scaled to a maximum of +10 V. The electrometers have different gains depending on the relative compositions

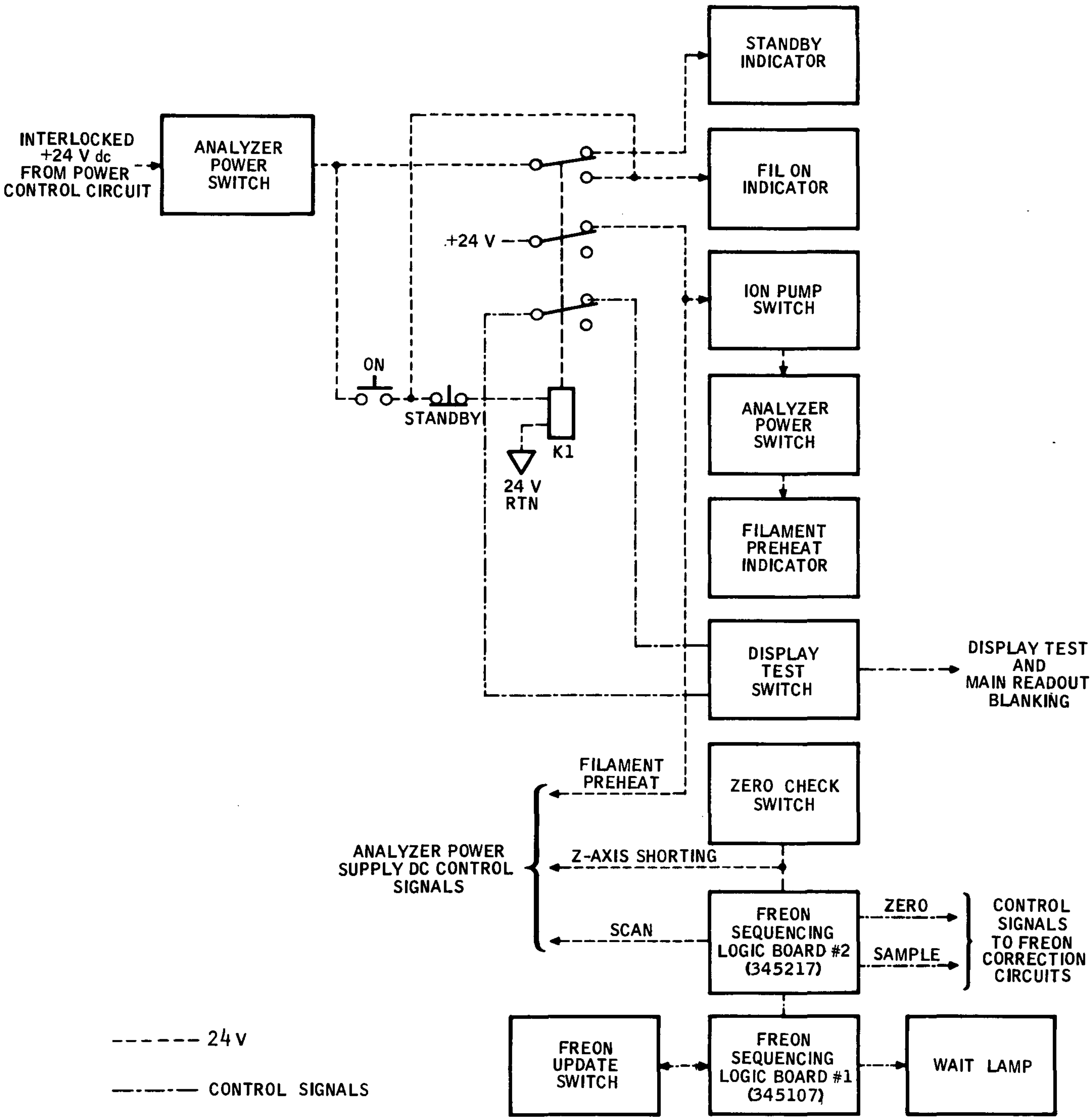


FIGURE 1-13
Analyzer Control Circuit Functional Diagram

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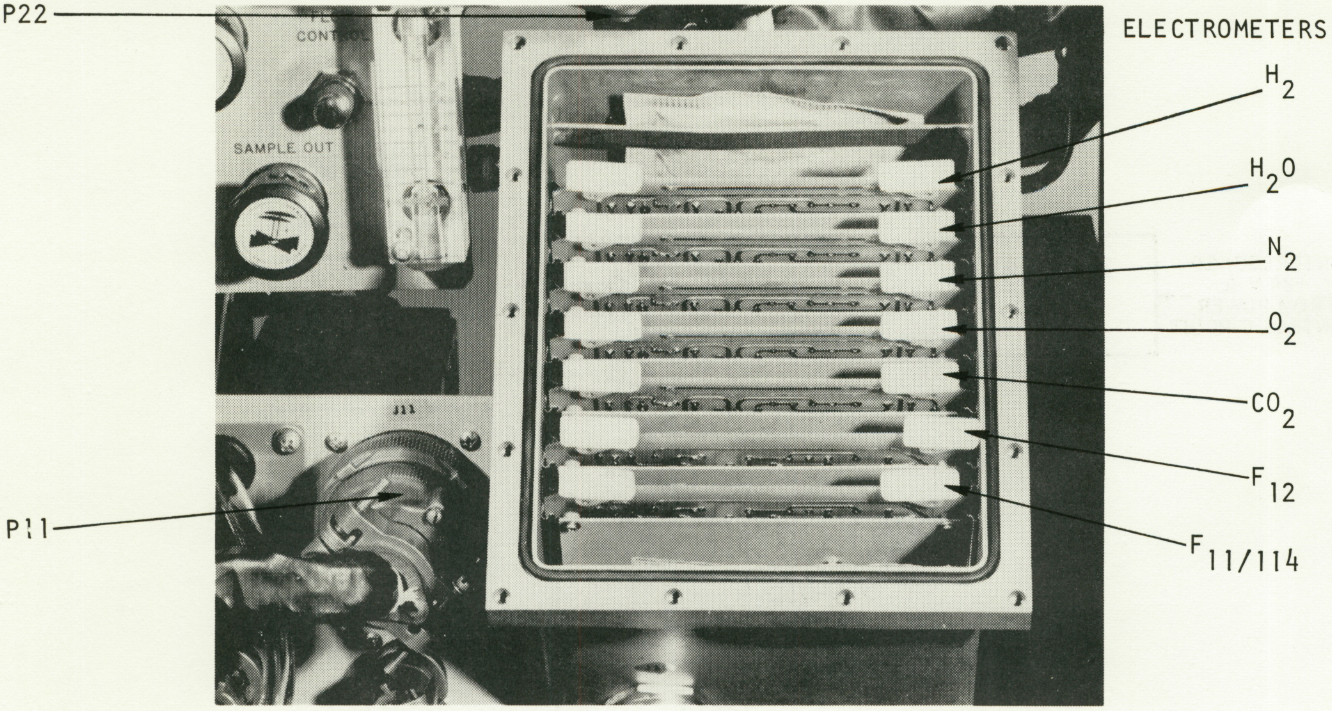

FIGURE 1-14
Electrometer Assembly

of the gases and the relative efficiencies of the analyzer. The freon electrometers are the most sensitive and use MOSFET transistors which have very low leakage and allow the use of very large feedback resistors for high gain.

The outputs of the freon electrometers go to the freon correction boards (see Figure 1-15) while all the other outputs go directly to the ratio boards. Each ratio board has four variable gain amplifiers which are controled by a signal from the summing board. All the amplifiers are controlled by the same signal and a change in that signal causes all the amplifiers to change their gain by the same factor.

The outputs of the ratio boards for all the channels except the freons are fed to the summing amplifier where they are added together along with a signal which simulates a constant 1% argon contribution. The transducer amplifier supplies the summing board with a voltage which is directly proportional to the ambient atmospheric pressure. This signal is inverted and applied to the summing amplifier which in effect subtracts the transducer signal from the sum of the ratioed gas signals. If the sum of the partial pressures of the gases is not equal to the ambient pressure the output of the summing amplifier will be a non-zero voltage. This will cause the pulse width modulator to change the width of its output pulses which control the ratio amplfiers. The ratio amplifiers increase or decrease their gain to make the summing amplifier output zero. In this way all the channels are compensated for changes in analyzer pressure and changes in ionizing current and ionizing efficiency.

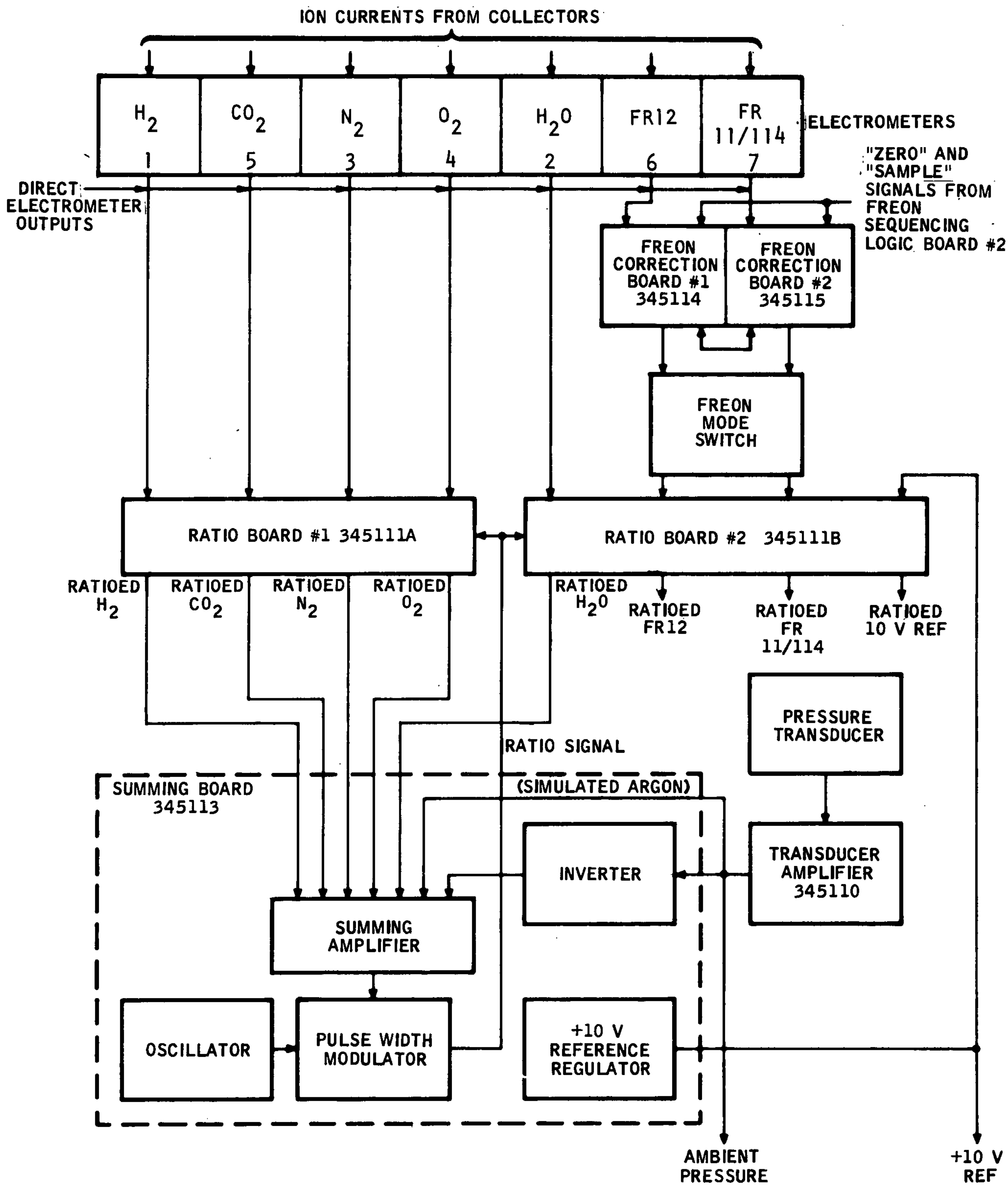

FIGURE 1-15
Signal Processing Circuits

The freon electrometers are much more sensitive than the other electrometers and as such are more subject to drift. On command from the Freon sequencing boards, the Freon correction boards automatically sample and hold the output of the freon electrometers under zero signal conditions (effected by grounding one of the z-axis plates, also by command from the freon sequencer boards). The analyzer is then returned to its operational state and the output of the freon correction board is the difference between the full signal and the zero signal levels. Freon 114 is detected on the same collector as Freon 11 by shifting the ion accelerating and focusing potentials. The F114 value is stored by a sample and hold circuit on freon correction board No. 2 when the accelerating potentials are returned to normal. The interferences present between the freons is accounted for by subtracting a percentage of the F11 or F114 signal from the F12 level. The analyzer can be programmed to detect either F11 and F12 or F12 and F114 by a toggle switch mounted on the card rack (see Figure 1-5). The outputs of the freon correction boards are ratioed by ratio board No. 2 and then are sent to the multiplexer along with the other ratioed gas signals.

A switched panel meter is provided for monitoring some of the voltages present in the instrument. The thermocouple amplifier is read in the first switch position. Full scale indicates atmospheric pressure while 2 μA is equivalent to an analyzer pressure of 10 microns. The ionizing current (I_{AN}) in the source region is read in the second position with a full scale indication of 50 μA. A portion of the electron beam will strike the accelerator element before reaching the ionizing region causing a current (I_{EA}) which is indicated in the third switch position with a full scale sensitivity of 200 μA. Two ranges are available for monitoring ion pump current (I_{IP} = 200 μA and I_{IP} = 200 mA full scale). On initial start up after roughing down the system the ion pump current may be as high as 150 mA which is the maximum supply current. Normal operating current will be about 100 to 200 μA.

1.4.1.4 Digital Signal Processing Circuits

The digitizer receives analog signals from the analog signal processing circuits and presents their amplitudes as visual information. The digitizer consists of three major functional blocks:

a. The multiplexer which samples each of (up to) eight individual analog input signals and presents those signals one at a time in sequence to the analog to digital converter.

b. The analog to digital converter which converts the analog signal at its input to a digital pulse train whose length is proportional to the amplitude of the input.

c. The display channel circuitry which counts the pulses of the variable length pulse train from the analog to digital converter and presents a visual display equivalent to the number pulses in that train.

The multiplexer accepts eight analog signals and time sequences these onto a single output line. The multiplexer runs at a 16 Hz rate, providing two samples of each input signal per second. The timing for this function is supplied by the analog to digital (A/D) converter via the "advance" line. The "enable" lines supply the signals to the display channel boards that allow the displays to be updated only when the multiplexer is passing their corresponding analog signal to the A/D converter. Each display is therefore dedicated to one particular analog input channel. The multiplexer also supplies signals to the Freon sequencer logic (described elsewhere). The range of analog input signals acceptable to the multiplexer is from approximately -2 V dc to +15 V dc. Anything more negative than -2 V at any input may impede proper operation of all inputs.

The analog to digital converter accepts each of the analog signals as supplied by the multiplexer and generates a train of pulses whose length is proportional to the amplitude of the analog signal. A 2 MHz clock provides all basic timing for the converter. The conversion process is controlled through a logic network and is initiated at a 16 Hz rate by a time base in the converter circuitry. A precision -10.00 V temperature compensated reference source establishes the basic accuracy of approximately ±0.1% full scale plus one digit uncertainty. The display channel circuitry receives the pulse train through a gating network, driven by the enable signal from the multiplexer, and passes it into a counter. The output of the counter is displayed on the 7-segment light emitting diode (LED) displays.

The Freon sequencer logic provides timing signals for the freon update cycle. The basic timing source is the 16 Hz update rate from the digitizer. The timing signals generated drive the scan and Z-axis relays in the analyzer power supply, two auto-zero networks and a sample and hold circuit on the freon correction boards, an inhibit line to the digitizer and the "wait" indicator lamp on the digitizer. Inputs to this circuitry include the "advance" signal and two synchronizing signals from the digitizer and an initiation signal from the FREON UPDATE pushbutton switch on the readout display panel.

The freon sequencer logic circuits provide many controlling signals which govern the operation of the analyzer and signal processing circuits during the freon update cycle. Figures 1-16a and 1-16b show a time sequence diagram of these signals as they actually appear. The signals are labeled as follows:

	NAME	FUNCTION
1)	SCAN	Turns on scan relay (in analyzer power supply)
2)	Z-AXIS	Turns on Z-Axis relay (in analyzer power supply)
3)	S1 and S2	Auto-zero signal to Freon Correction Boards
4)	S3	Sample and Hold signal to Freon Correction Boards
5)	INHIBIT	Instructs the multiplexer to update the freon displays
6)	RST RST*	Two reset signals that turn on the freon sequencing logic circuits and determine either Mode 1 or Mode 2 operation.

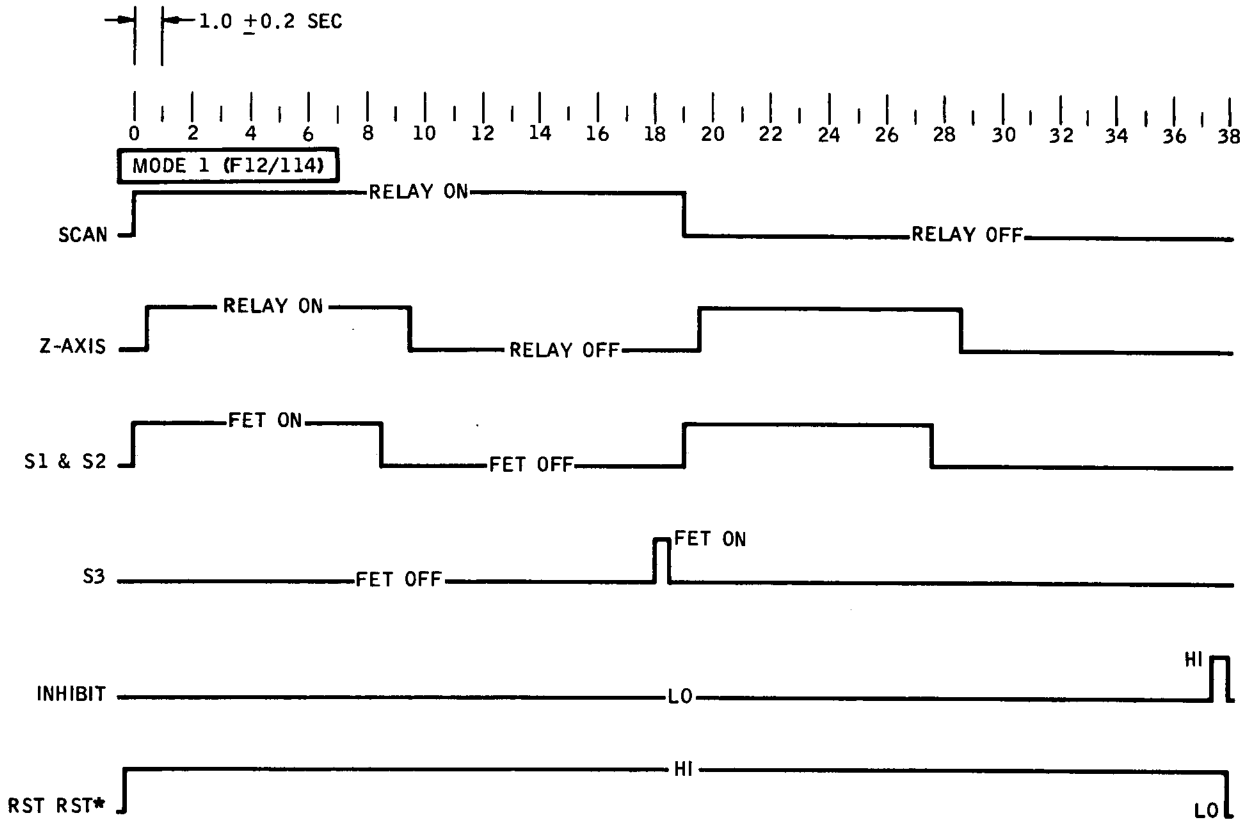

FIGURE 1-16(A)
Freon Logic Timing Diagram

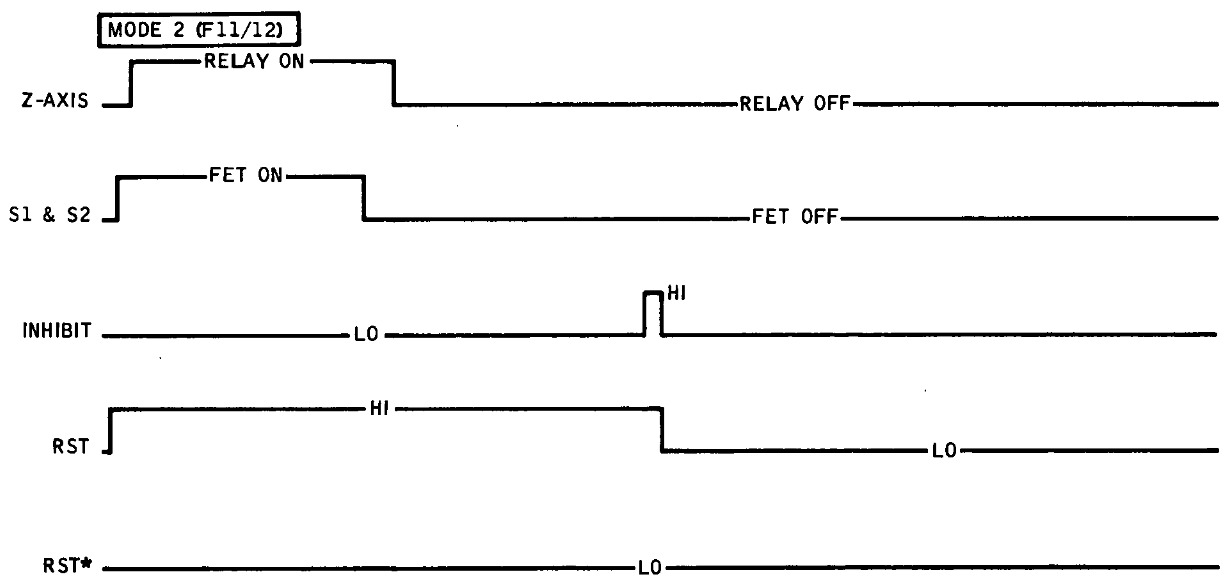

FIGURE 1-16(B)
Freon Logic Timing Diagram

Mode 1 operation will be thoroughly discussed as Mode 2 is just a shortened version of Mode 1. Freon 12 and Freon 114 are detected during Mode 1 operation and Freon 11 and Freon 12 are detected during Mode 2 operation.

All action is initiated by pushing the update button on the display panel (see Figure 1-5). When this button is pushed the freon updating sequence is initiated and proceeds as follows:

a. Four events occur immediately:

   1. The wait light comes on and stays lit until the freon update is completed. No readings should be taken from the digital displays while this light is on.

   2. The scan relay closes and lowers the ion accelerating and focusing voltages.

   3. The auto-zero circuits on the Freon Correction Boards are activated by S1 and S2.

   4. The reset signals (RST and RST*) come on and activate the Freon Sequencer logic circuits.

b. One-half second later the z-axis relay is closed, to ground one of the z-axis plates preventing ions from entering the analyzer. All electrometers therefore have a zero input signal and the output of each electrometer is its dc offset voltage. The dc offset of the freon electrometers is compensated for by the auto-zero circuits on the Freon Correction Boards.

c. Eight and one-half seconds later the auto-zero signals are removed and the auto-zero circuits remember the dc offsets of the freon electrometers.

d. one second later the z-axis relay opens and the z-axis plate returns to its normal potential. The analyzer is now functioning in its scan mode and is detecting Freon 114.

e. eight seconds later the Freon Correction Boards receive a sample and hold signal (S3) telling them to remember the corrected Freon 114 signal for future display.

f. Two events occur at this time:

   1. The SCAN relay turns off returning the ion accelerating and focusing voltages to normal.

   2. The auto-zero signals (S1 and S2) are again sent to the Freon Correction circuits.

g. One-half second later the z-axis relay is again turned on and one of the z-axis plates grounded.

h. Eight seconds later the auto-zero signal is removed and the dc offset of the two freon electrometers is remembered.

i. One second later the z-axis relay opens and the z-axis plate returns to its normal potential.

j. Eight and one-half seconds later the inhibit signal is sent to the multiplexer. Normally the multiplexer only samples the H_2, O_2, CO_2, and test DVM channels. When this inhibit signal is received the multiplexer makes one complete cycle, sampling H_2, O_2, CO_2, test DVM, F114 and F12 signals (this takes about 1/2 second). The next multiplexer cycle, which follows immediately, will sample only the first four signals as previously indicated. The F114 and F12 displays will remain fixed until the next freon update cycle is initiated and completed.

k. One-half second later the reset signals (RST and RST*) are removed and the freon sequencer logic circuits are turned off. The wait light goes out at this time. The entire freon update has taken about 38 seconds.

Mode 2 operation is simpler because Freon 11 and Freon 12 are detected during normal analyzer operation, hence the ion accelerating voltage does not need to be shifted. For that reason the SCAN signal is not shown in Figure 1-16b. Since the Freon 11 and Freon 12 signals are present together there is no need for a sample and hold signal and S3 is not shown in the timing diagram. The sequence of operation for detecting Freon 11 and Freon 12 can be understood by beginning at Step f2 of the Mode 1 description above and continuing through Step j (insert the words Freon 11 where Freon 114 is mentioned in Step j). The first 19 seconds of the Mode 1 cycle are bypassed because the RST* signal is not present to turn on the part of the circuit that generates the first half of the Mode 1 cycle. At the end of the Mode 2 cycle the RST signal is removed, turning off the freon sequencer logic circuits and the wait light. Mode 2 requires about 19 seconds for a complete update.

Mode 1 or Mode 2 operation is selected by a switch located on the card rack behind the plug-in cards. The switch has been set by the manufacturer to meet the requirements of the particular installation and will not need to be changed while remaining in that installation.

2. OPERATIONAL PROCEDURES

2.1 START UP PROCEDURES

a. Remove all front panels

b. Loosen and swing down the digital display

c. Check the following switch positions before attaching power cord to electrical outlet.

   1. Power circuit breaker, and all power control switches on control panel - OFF

   2. Analog monitor - TC

   3. Digital test meter - +24 V

   4. Emission adjust pot (I EMIS) - FULL CCW

   5. Filament select switch (FIL) - FIL #1 or #2

   6. EMISSION switch - I_{AN}

   7. FREON STEP switch - NOR

d. Check the following control positions before turning electrical power ON.

   1. Variable leak valve - closed - FULL CW

   2. Rough line isolation valve - closed - FULL CW

   3. Rough pump isolation valve - closed - FULL CW

   4. SAMPLE IN and SAMPLE OUT shut off valves - closed - FULL CW

   5. Vent valve - closed - FULL CW

e. Attach the power cord to an appropriate outlet; 115 V ac 30 amp

f. Turn the POWER circuit breaker on; this activates the cooling fans. Verify fan operation.

g. Turn the L.V. P/S switch ON. This activates all the low voltage power supplies and thermocouple gage vacuum indication (TC). Verify all low voltage power supplies with digital test meter. Verify TC with analog meter. Allow about 1 minute warm up for the TC circuit. If the TC reading is above 2 μA (on the 0-20 μA scale) and the ROUGH COMP lamp does not light, the vacuum system will have to be roughed down with the external mechanical roughing pump (see Section 2.2).

h. When the ROUGH COMP lamp lights turn the analog meter switch to I_{IP} (200 mA).

i. Turn the ION PUMP power switch ON and observe the ion pump current. As the pressure reduces the ion pump current will go down and its progress can be observed. By referring to Figure 2-1 the relationship between pressure and current can be made.

j. When the ion pump current drops to less than 5 mA, the M.S. P/S switch can be turned to ON. This will activate all the power supplies associated with the operation of the mass spectrometer within the vacuum housing. This can be verified by observing the VACC reading on the test DVM. Refer to manufacturer's test data for your particular instrument for the correct value of VACC. The FIL PREHEAT light will come on indicating that the filament is in a warm condition, i.e., half power.

k. Next the HEATER switch should be turned on. This will activate both the ion source and inlet leak heaters. This operation can be monitored on the TV and TS positions of the analog meter. Time is required for the heaters to reach equilibrium. The source heater equilibrates in about 20 minutes and at least 1 hour is required for the valve heaters. The temperature of the valve must be stable before it is opened (Step p). This can be determined by observing that the TV readout is constant. Refer to manufacturer's test data for your particular instrument for the correct value of TV.

ℓ. The SAMPLE PUMP should now be turned ON and a sample flow established in the inlet system. Open (CCW) both the SAMPLE IN and SAMPLE OUT valves (green handles). Rotate the SAMPLE SELECT valve to SAMPLE position. Adjust the FLOW CONTROL needle valve for a flow of 0.04 SCFH on the FLOW METER.

m. When the ion pump current (I_{IP}) decreases to less than 1 mA the STANDBY switch-light will come ON indicating that the system is now ready to be turned on and set up for normal operation. On an initial system start up the system should not be turned ON until a reasonable background pressure level has been established well below 50 μA ion pump current. This should be checked on the IP 200 μA range.

n. Once the background pressure has been established the mass spectrometer should be turned on by pressing the ON switch-light.

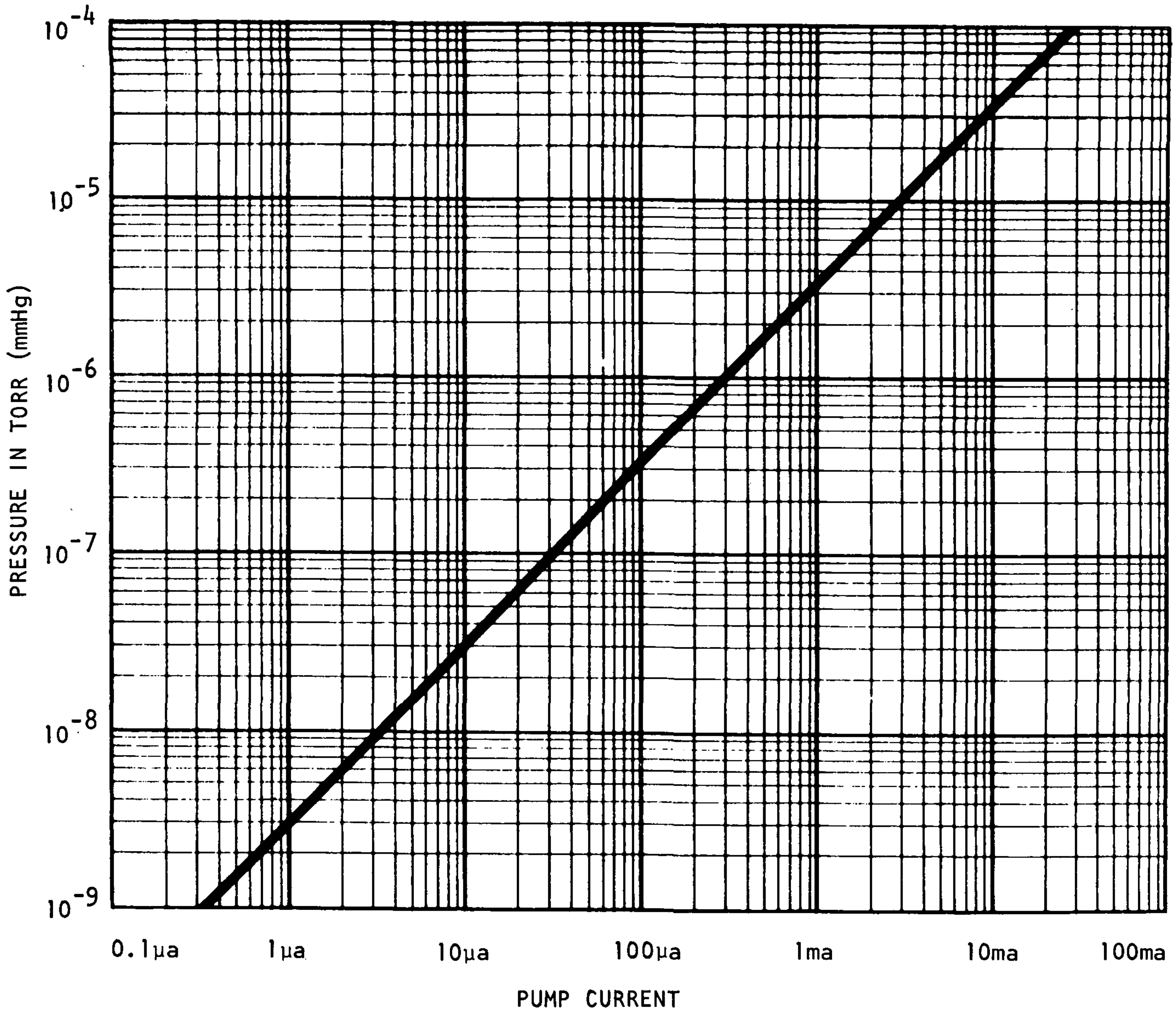

FIGURE 2-1
Pressure Vs Ion Pump Current

o. The ion source emission level should next be turned up to the value supplied with the manufacturer's data as indicated on the analog meter in the I_{AN} position. The emission is adjusted with the I EMIS pot located in the upper module behind the digital display. The ion source operation can be verified by observing the I_{EA} current on the analog meter. Refer to manufacturer's data for the nominal value of I_{EA}.

p. If all the preceding steps have been performed and verified, particularly the valve heater, the inlet leak valve may be opened (CCW). Place the analog test meter switch in the I_{IP} (200 μA) position BEFORE starting to open the valve. Use EXTREME CAUTION while opening this valve. Its opening characteristics are nonlinear with rotation, i.e., the first few turns seem to accomplish no change then the valve opens suddenly. Carefully open the valve until an indication is seen on the I_{IP} monitor and then adjust the value to the current suggested in the manufacturer's data. Then wait 5 minutes to allow for stabilization during which time the valve may have to be readjusted. Next check the N_2 direct output to see that it is within 10% of the value given in the manufacturer's data. If it is not, adjust the valve until the N_2 direct output is within ± 0.200 volts. If necessary, establish a new set point for the ion pump current.

q. Press the UPDATE button on the digital display to clear and set up the Freon measurement circuits.

r. The system is now fully operational. System calibration verification can be performed (see Section 2.4) or the system can be placed on line for atmospheric measurement.

2.2 ROUGH PUMPING PROCEDURE

This procedure is used only if the analyzer has been vented or if the ion pump has been turned off long enough for the analyzer pressure to rise above 1 μA as indicated by the TC position on the 0-20 μA scale of the analog meter. The purpose of rough pumping is to reduce the pressure within the analyzer to a level from which the ion pump can start pumping. The rough pump should be valved off as soon as possible after the ion pump has started.

CAUTION

> There is an interlock on the ROUGHING LINE VALVE that prevents the ion pump from coming ON until the valve is fully closed. Care should be exercised in any case since malfunction or misadjustment of the device could allow the ion pump to turn on with the valve open.
>
> Prolonged operation of the ion pump with the ROUGHING LINE VALVE OPEN can damage the ion pump.

The accessory equipment, ROUGH PUMP AND TRANSIT CASE ASSEMBLY, 345438, is required for rough pumping.

a. Open the transit case, check the pump oil level, check the vacuum line and its connections.

b. Check the ROUGH PUMP ISOLATION VALVE, it shall be closed.

c. Remove the VACUUM COUPLING protective cap and attach the vacuum hose from the external pump. Hand tighten the coupling securely.

d. Check the line switch in the rough pump power cord, it should be in the off position. Plug the line cord into the accessory outlet in the lower left corner of the cabinet.

e. Turn on the rough pump and allow it to pump down for about two minutes before opening the ROUGH PUMP ISOLATION VALVE.

f. Open the ROUGH PUMP ISOLATION VALVE and rough down the filter trap and lines up to the analyzer Roughing Valve for at least 5 minutes.

g. The initial start up procedure should be performed up to Step g with the analog meter reading TC with the exception of 2.1d.2. The rough line isolation valve should be OPEN.

h. Open the VACUUM HOUSING ROUGHING VALVE and observe the pump down rate on the analog meter TC position.

i. When the TC reading reaches approximately 2 μA on the 0-20 μA scale, the ROUGH COMP. lamp will light. When this occurs, close the VACUUM HOUSING ROUGHING VALVE, turn analog meter switch to I_{IP} (200 mA) and set the ION PUMP switch to ON. The ION PUMP light should light immediately.

j. The ion pump current may go as high as 150 mA for a few minutes but should begin to decrease. If it does not it is due to outgassing from the ion pump and the analyzer will require further roughing. Turn OFF the ION PUMP and return to Step h above and continue to this step until the ion pump catches and begins to pump. (Note this might require several iterations.)

k. Once the ion pump has started and is pumping down satisfactorily the rough pump isolation valve should be closed. This completes the rough pumping procedure.

l. Turn off the rough pump, remove the vacuum hose from the vacuum coupling and replace the protective cap. Secure the rough pump in its transit case.

m. The start up procedure may now be continued starting with 2.1h.

2.3 OPERATIONAL VERIFICATION PROCEDURE

The Atmospheric Contaminant Sensor has been designed to operate for extended periods of time under severe environmental conditions without any monitoring or adjustment. The system has been calibrated; both zero and span of all channels have been set and should not require readjustment during normal use.

The following check list is given as a guide to use in verifying all the switch and control positions for normal system operation:

a. Verify that the sample transport line is attached to the SAMPLE INLET and that all external valving or plumbing is not plugged or kinked.

b. Remove the front panels.

c. Ensure that all switches, controls and meters listed below are positioned or reading as indicated for normal operation.

1.	POWER circuit breaker	ON
2.	L.V.P/S	ON
3.	ION PUMP switch	ON
4.	M.S.P/S	ON
5.	SAMPLE PUMP switch	ON
6.	HEATERS switch	ON
7.	T.C. Override	OFF
8.	FIL	ON
9.	Analog Test Meter	I_{IP} (200 μA)
10.	Digital Test Meter	P_{AMB}
11.	SAMPLE IN valve	Open
12.	SAMPLE OUT valve	Open
13.	Flow Meter (Flow Control)	0.04 SCFH

d. Record all analog test meter and test DVM readings and compare to Table 2-1. The readings should all fall within the ranges specified. If any are out of tolerance refer to Section 3.

The following procedure is given as a guide for the operator to use in taking system data and checking on system operation.

a. Record the operational data from the DIGITAL DISPLAY on a data form similar to Figure 2-2. This data should be recorded at consistent intervals such that any trends can be observed prior to reaching a level that requires an action to change the trend.

TABLE 2-1

Test Display Nominal Values

Analog/ Digital Position	Nominal Value	Tolerance High	Tolerance Low	Function
TC	0.5 μA	1.0 μA	0.0 μA	Vacuum Housing Pressure
I_{AN}	37.5 μA	38 μA	37 μA	Ionization Current
I_{EA}	100 μA	110 μA	90 μA	Electron Gun Tuning Indicator
I_{IP}	100 μA	130 μA	80 μA	Vacuum Housing Pressure (operational)
+24 V	28 V	32 V	24 V	L.V. P/S Output
+15 V	15 V	15.2 V	14.5 V	L.V. P/S Output
-15 V	15 V	15.2 V	14.5 V	L.V. P/S Output
+5 V	5 V	5.2 V	4.8 V	L.V. P/S Output
V_{ACC}	*	*	*	M.S. P/S Indicator
TV	8.0 V	8.4 V	7.6 V	Valve Temperature Indicator
TS	8.0 V	8.4 V	7.6 V	Source Temperature Indicator
N_2	Variable - depending on sample			Ratioed N_2 Output
H_2O				Ratioed H_2O Output
P_{AMB}	Local Ambient	+5 torr	-5 torr	Pressure Transducer Output
1	Variable - depending on sample			H_2 Electrometer Output
2				H_2O Electrometer Output
3				N_2 Electrometer Output
4				O_2 Electrometer Output
5				CO_2 Electrometer Output
6				Freon Electrometer Output
7				Freon Electrometer Output

*Supplied as manufacturer's data with each instrument.

D

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ATMOSPHERE CONTAMINANT SENSOR
OPERATIONAL DATA LOG

DATE ____ PAGE ____ OF ____

GAS	COMP'T	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
OXYGEN 140 - 160 TORR (17 - 21%)	FAN ROOM																									
CARBON DIOXIDE <7.6 TORR (11.4 TORR MAX)	FAN ROOM																									
CARBON MONOXIDE < 20 MILLITORR	FAN ROOM																									
REFRIGERANT - 12 <76 MILLITORR (380 MILLITORR MAX)	FAN ROOM																									
REFRIGERANT - 114 <19 MILLITORR	FAN ROOM																									
HYDROGEN <11.4 TORR	FAN ROOM																									
NITROGEN	FAN ROOM																									
P_{AMB}	FAN ROOM																									

PORTABLE DAILY READINGS	TIME	REMARKS	TIME	REMARKS	TIME	REMARKS
TIME OXYGEN ____ % ____ CO_2 ____ % ____ CO ____ PPM ____ OTHER **NOTE** GRAPH ALL FAN ROOM READINGS ON THE REVERSE SIDE.						
REVIEWED BY						

F-402

FIGURE 2-2 (Sheet 1 of 2)

Operational Data Log

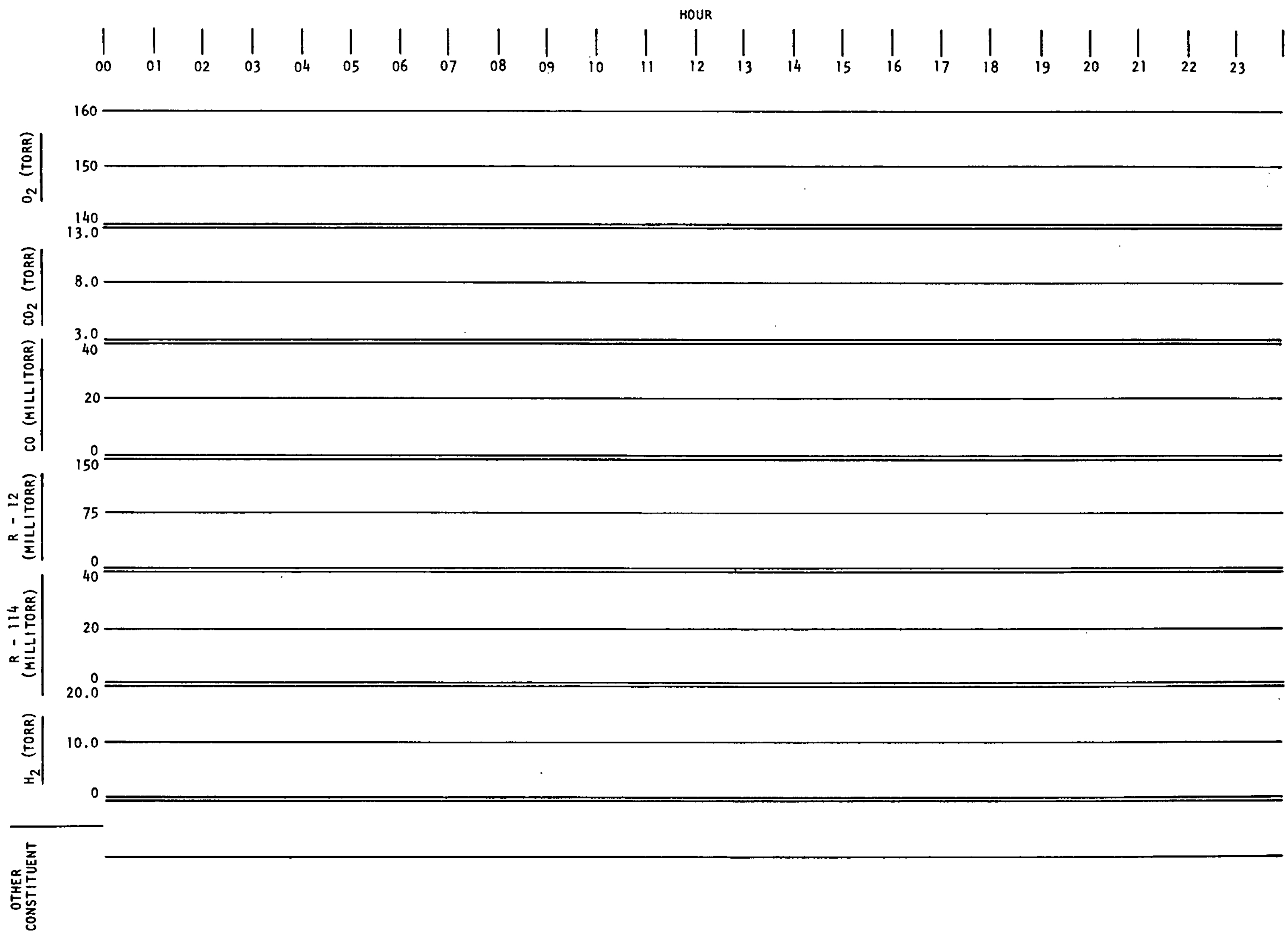

FIGURE 2-2 (Sheet 2 of 2)
Operational Data Log

b. Record the test point data from the CONTROL PANEL test meters on data forms similar to Figures 2-3 and 2-4. This data should also be recorded at consistent intervals such that any trends can be observed prior to reaching a level that requires an action to change the trend. These trends will be of a very slow nature and a daily set of data is probably adequate.

c. A first level check on system performance when monitoring an ambient atmosphere can be made by summing the partial pressures of H_2, O_2, and CO_2 as read on the digital display meters and H_2O and N_2 as read on the test DVM meter. The partial pressure of argon must also be summed since it is a constant partial pressure in most atmospheres, it is sufficient to take 1% of the P_{AMB} reading from the test DVM. The summation of the atove partial pressures of H_2, O_2, CO_2, N_2, H_2O, and A should compare to the P_{AMR} reading from the test DVM within ± 2 or 3%. If the summation appears to be normal, then no further check is necessary. If the summation appears to be abnormal a further check of the calibration should be made as described in the Calibration Verification Procedure, Section 2.4.

2.4 CALIBRATION VERIFICATION PROCEDURE

The purpose of this procedure is to verify the calibration of the ACS. It is not a recalibration procedure. None of the adjustments called out in this procedure will alter the calibration. If the verification does not prove acceptable refer to Section 3. Troubleshooting.

a. Observe and record a full set of readings, Operational Data form (Figure 2-2) and Test Point Data form (Figure 2-3).

b. Switch the Sample Select valve to CAL inlet.

c. Set the analog test meter to P_{AMB} and admit the calibration sample mix and pressurize to about 60 torr above the initial P_{AMB} reading to assure no errors due to local ambient gas entering the inlet system.

d. Open the FLOW CONTROL valve full for about one minute. Observe the H_2 and CO_2 direct output reading rise and stabilize. Then reduce the flow with the FLOW CONTROL valve to the standard setting, 0.04 SCFH.

e. Reduce the calibration mix applied pressure to 30 torr above the ambient pressure as indicated by the P_{AMB} readout, allow one minute and depress the UPDATE button.

f. Calculate the partial pressures of the calibration mix based on the applied pressure in e above. The measured partial pressures should agree with the calculated partial pressures within the tabulated limits when the H_2O output decreases to less than 2.0 torr:

H_2 ± 4 torr	F12 ± 23 m torr
O_2 ± 10 torr	F11 ± 4 m torr

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ATMOSPHERE CONTAMINANT SENSOR
TEST POINT DATA LOG

SHEET 1 OF 2

DATE	TIME	SAMPLE FLOW RATE	TEST PANEL DATA												REMARKS	DATA BY
			TC	I_{AN}	I_{EA}	I_{IP}	+24 V	+15 V	-15 V	+5 V	V_{ACC}	TV	TS	GAIN		

FIGURE 2-3

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AEROSPACE DIVISION
SHEET 2 OF 2

ATMOSPHERE CONTAMINANT SENSOR
TEST POINT DATA LOG

DATE	TIME	TEST PANEL DATA (CONTINUED)											REMARKS	DATA BY
					DIRECT OUTPUTS									
		N_2 (TORR)	H_2O (TORR)	P_{AMB} (TORR)	1 (H_2)	2 (H_2O)	3 (N_2)	4 (O_2)	5 (CO_2)	6 (F12)	7 (F11)	REF		

FIGURE 2-4

CO_2 ±1.3 torr F114 ±23 m torr

H_2O ±4 torr

N_2 ±28 torr

g. Switch the Sample Select Valve back to the SAMPLE INLET position. Shut off the calibration mix bottle to avoid calibration mixture loss. Open the Flow Control Valve full for one minute while observing the H_2 and CO_2 outputs decrease and stabilize. Close the Flow Control Valve to a flow rate 0.04 SCFH. Press freon UPDATE button.

h. Take normal set of readings on Operational Data form (Figure 2-2).

2.5 SHUT DOWN PROCEDURE

This procedure defines the method that must be followed to shut down the ACS for maintenance, removal from installation, or long periods of nonuse.

2.5.1 SHUT DOWN - STANDBY LEVEL FOR LONG PERIODS OF NONUSE

a. Press the STANDBY light switch.

b. Close (CW) the HEATED INLET valve.

c. Close (CW) both the SAMPLE IN and SAMPLE OUT valves.

d. Set the SAMPLE PUMP switch to OFF.

e. Set the HEATERS switch to OFF.

f. Set the M.S. P/S switch to OFF.

2.5.2 SHUT DOWN - COMPLETE POWER OFF

a. Complete Paragraph 2.5.1 above.

b. Set the ION PUMP switch to OFF.

c. Set the L.V. P/S switch to OFF.

d. Set the POWER circuit breaker to OFF.

2.6 FILAMENT SWITCH-OVER PROCEDURE

If the operational filament should fail or burn out, the redundant filament may be activated by the following procedure:

a. Press the STANDBY light switch.

b. Turn the I EMISS fully CCW to turn off the filament drive.

c. Switch the FIL SEL switch to the remaining good filament.

d. Switch the ANALOG TEST METER to I_{AN}.

e. Press the ON light switch.

f. Turn the EM. ADJ (CW) cautiously until anode current is observed in the ANALOG TEST METER. Then turn the anode current up to the value supplied with the manufacturer's data.

g. Ensure that the I_{EA} is within tolerance. Analog test meter - I_{EA} position.

h. The system is now fully operational again and may be verified as outlined in Paragraphs 2.3 and 2.4.

2.7 ACCIDENTAL VENTING RECOVERY PROCEDURE

If the system is accidentally vented, the procedure outlined in Paragraph 2.2 should be followed.

2.8 POWER FAILURE RECOVERY PROCEDURE

The system is designed to automatically recover to the STANDBY condition from a power failure of approximately one hour duration. If the power failure is longer, the outgassing within the vacuum housing may raise the pressure above the starting point for the ion pump. In this case, the ion pump will not turn on and the system must be externally roughed down as outlined in Paragraph 2.2.

3. MAINTENANCE AND TROUBLESHOOTING

The purpose of the troubleshooting guide presented in this section is to allow the operator to isolate failures within the system and to take corrective action. There are certain limitations to this guide which should be recognized before it is used. The guide is not intended to be all inclusive. There are undoubtedly failure modes which have not previously been experienced or have not been anticipated. However, the guide does present the majority of the possible failure modes and corrective actions for them.

The guide has in general been tailored to the level of spares provisioning for the ACS. As a result, the fault isolation procedures will only take the operator to the printed circuit board level. In some instances it goes to the component level where the component is mounted on the chassis. At other times (e.g., the analyzer power supply module), the fault isolation is actually taken only to the module level. In all cases schematic drawings have been provided separately which would allow a knowledgeable person to carry out further fault isolation.

The list below gives the location within the ACS of the printed circuit boards for which spares are provided.

IDENTIFICATION	DESCRIPTION	LOCATION
345110	Transducer Amplifier	Card Rack
345111A	Ratio Board No. 1	
345113	Summing Board	
345111B	Ratio Board No. 2	
345114	Freon Correction Board No. 1	
345115	Freon Correction Board No. 2	
345107	Freon Sequence Logic No. 1	
345217	Freon Sequence Logic No. 2	
345233	Multiplexer	Display Module
345106	A/D Converter	
345105	Display Channel Board	
345098	Source Temperature Control	Support Module
345099	Valve Temperature Control	
345100	Vacuum Control Board	
345097	Relay Board	
345096	Power Supply	
345121	Electrometers (5)	Electrometer Housing
345122	Electrometers (2)	
345118	Emission Regulator	Analyzer Power Supply
345119	Bias Board No. 1	
345120	Bias Board No. 2	

The guidelines provided for troubleshooting are primarily intended for the electronics subsystem. If a failure should occur within the vacuum envelope (i.e., to the analyzer or the ion pump), the guide does not provide for corrective action other than return of the entire unit to the manufacturer for repair.

There are quite a few potentiometer adjustments on the system most of which are associated with the analyzer power supply module and the signal processing electronics. These adjustments are, with a very few exceptions, set at the factory and are for manufacturer's use only.

Below is a list of cards that are used in the analog signal processing chain.

NOTE

If any one of them are to be replaced they must all be replaced. These cards are calibrated as a set and the system accuracy will be seriously degraded if they are not replaced as a set.

IDENTIFICATION*	DESCRIPTION
345111A	Ratio Board
345111B	Ratio Board
345114	Freon Correction Board No. 1
345115	Freon Correction Board No. 2
345121	Electrometer (five units)
345122	Electrometer (two units)

A Troubleshooting Reference Guide (Table 3-1) has been provided which references paragraphs of the guide to the paragraphs of the foregoing procedures. In this way, if the operator detects a possible failure at a particular step in the procedure which he is following, he can quickly find the appropriate corrective action in the troubleshooting guide by referring to the Troubleshooting Reference Guide.

CAUTION

NOTE 1:

Any time a connector is to be disconnected or a circuit card is to be removed, the instrument power must be turned OFF. If a voltage measurement is to be made or a new card tried the power turn on sequence must then be followed. Failure to follow this procedure may result in damage to the electronic circuitry. If a resistance measurement is to be made, all power should be turned OFF.

NOTE 2:

Any time that it is necessary to power down the system, as indicated by the troubleshooting guide or as dictated by Note 1 above, it is necessary to follow the shut down procedure outlined in Paragraph 2.5. In particular, the inlet leak valve must be closed prior to powering down.

TABLE 3-1

Troubleshooting Reference Guide

Problem	See Symptom No.	Reference Section
1. Fans do not operate	2A	2.1f
2. Digital test meter indicates one or more low voltage supplies is malfunctioning	4D	2.1g
3. TC reading is below 2 μA but ROUGH COMP light fails to come on	8B	2.1g
4. Ion pump current is zero when ion pump is turned on	5H	2.1j
5. Ion pump light does not come on	5B	2.1i
6. Ion pump current does not decrease from maximum (150 mA)	Refer to rough pump procedure 2.2j	2.1i
7. Ion pump light comes on but then goes out	5B	2.1i
8. V_{ACC} reading not correct when M.S.P/S is turned on	6A	2.1j
9. The TS or TV reading is out of specification	7A	2.1k
10. No sample flow can be obtained	3A	2.1ℓ
11. The "STANDBY" light does not come on	10A	2.1m
12. The "ON" light fails to turn on	11A	2.1n
13. No I_{EA} or I_{AN} current on front panel analog meter	6I	2.1o
14. No N_2 output when leak valve is opened	15	2.1p
15. Pressing update button does not clear Freon displays	14A	2.1q
16. TC reading fails to come down	8	2.2i

TABLE 3-1 (Cont)

Problem	See Symptom No.	Reference Section
17. Ion pump fails to start even though the TC pressure is low enough	5	2.2k
18. Test point data incorrect		2.3b
I_{AN} incorrect	15e	2.3b
I_{EA} incorrect	15e	2.3b
I_{IP} incorrect	15c	2.3b
+24 incorrect	4	2.3b
+15 incorrect	4	2.3b
-15 incorrect	4	2.3b
+5 incorrect	4	2.3b
V_{ACC} incorrect	6	2.3b
TV incorrect	7	2.3b
TS incorrect	7	2.3b
19. Readings do not sum to P_{AMB}	15	2.3c
20. Test points incorrect	(See 19)	2.4a
21. Outputs out of tolerance	15	2.4f
22. Test points incorrect	(See 19)	2.3(d)

Troubleshooting Guide

Symptom	Action	Comments
1. Main power indicator does not light when main circuit breaker is turned on.	A. Check main power connection.	115 V ac will be present at the utility outlets if main power is O.K.
	B. Replace indicator light if fans are running.	115 V ac is present at control panel if fans are running.
2. Fans do not run.	A. Check fuse on fan housing. Clean air filters.	Fans run when main circuit breaker is on and main power indicator light is lit.
3. Sample will not flow.	A. Check sample pump fuse.	
	B. Check for plugged filters. Clean or replace as necessary.	
	C. Check for crimped flex lines.	
4. Low voltage not present	A. Check front panel fuse for low voltage power supply.	If fuse is blown proceed to Step F; if not, proceed to Step B.
	B. If test DVM is operational read +5 V, +15 V, -15 V and +24 V positions with "ion pump", "M.S. P/S" and "Heaters" switches off. If test DVM inoperable proceed to Step D.	Readings should be: +5 V $\pm$0.2 V +15 V $\pm$0.5 V -15 V $\pm$0.5 V 28 V $\pm$4 V
	C. If voltages are correct refer to troubleshooting information for card where voltage is absent or use system wiring diagram to trace voltage path. If voltages are incorrect proceed to Step D.	
	D. Disconnect P8 from J8 and P7 from J7 (see Figure 1-6). Remove the relay board and vacuum control board from the power control card rack. Turn on the low voltage power supply. The following voltages should be present at J7 and J8.	Removing J8, J7, the relay board and the vacuum control board disconnects most of the circuits that could possibly be loading the power supply. The outputs of the low voltage power supply may now be checked directly through the support module wiring. The +5 V dc and the $\pm$15 V dc supplies are

Troubleshooting Guide

<table>
<tr><th>Symptom</th><th>Action</th><th>Comments</th></tr>
<tr><td>4. Low voltage not present (cont)</td><td>D. (Cont)

From | To | Voltage
J7-T | J7-U | +28 V dc
J8-A | J8-B | +5 V dc
J8-C | J8-D | +5 V dc
J8-E | J8-F | +15 V dc
J8-H | J8-J | +15 V dc
J8-G | J8-F | -15 V dc
J8-K | J8-J | -15 V dc

If +5 V dc or ±15 V dc voltages are not present or are incorrect replace low voltage power supply board 345096. If 24 V dc supply is absent or incorrect, or replacing board does not correct problem check rectifiers, capacitors and transformer mounted on low voltage power supply chassis (see Figure 3-1).

If voltages are correct proceed to Step E.

E. Refer to troubleshooting information for card where voltage is absent, and use system wiring diagram to trace voltage path.

F. Replace low voltage power supply fuse (2A 3AG type only). Remove J7, J8, the relay board, the vacuum control board and the low voltage power supply board (345096). Monitor voltage between J7-T and J7-U. Turn on main power circuit breaker and L.V.P/S switch</td><td>current limited and will give a low output or none at all if an overloaded condition or short is present. The 28 V dc is not current limited and if shorted should cause the low voltage power supply fuse to blow.</td></tr>
</table>

Troubleshooting Guide

Symptom	Action	Comments
4. Low voltage not present (cont)	F. (Cont) Turn off immediately if 24 V dc supply is not present or if overload is suspected and check rectifiers, capacitors and transformer on low voltage power supply chassis. If 24 V dc supply is present and no overload is suspected proceed to Step G.	
	G. Turn off L.V.P/S switch and reinstall board 345096. Turn on L.V. P/S switch and measure voltages called out in Step D. If any voltages are absent or incorrect replace board 345096. If voltages are correct refer to system wiring diagram to trace voltage paths and correct overload conditions.	There are many return paths to ground and power supply common for the low voltage lines. When measuring resistance at P7 and P8. Check not only the voltage line and its associated return line but also all other power return and ground lines.
5. Ion pump power supply inoperative.	A. If ion pump "ON" light is lit proceed to Step H. If "Roughing Complete" light is lit proceed to Step B. Otherwise proceed to Symptom No. 8 troubleshooting.	Analyzer pressure must be below 10 microns to operate ion pump. TC position of front panel meter should indicate less than 2 μA and roughing complete light should be lit indicating that K2 has been activated.
	B. Turn off ion pump switch and wait about six minutes. If an overload was sensed the pump protection circuit will reset automatically. Monitor ion pump current on front panel meter while turning ion pump switch on. If no current is indicated proceed to Step C.	If an ion pump overload is present refer to Section 2.2 of Operational Procedures.

ε

Troubleshooting Guide

Symptom	Action	Comments
5. Ion pump power supply inoperative.	C. Check rough valve interlock switch, must be closed for pump to operate.	
	D. Remove P14 from J14. Measure voltage from P14-A to analyzer ground - should be 28 V dc. Check for continuity between J14-A and J14-B. If voltage and continuity are present proceed to Step G.	
	E. If 28 V dc is not present at P14 replace relay board 345097. If still no voltage proceed to Step F.	If replacing relay board cures problem relay K2 or K3 is probably defective.
	F. Replace vacuum control board 345100. If voltage is still not present use system wiring diagram to trace voltage from relay board to ion pump power supply.	Support module will probably have to be removed.
	G. The solid state ac switch in the ion pump power supply is probably defective. Remove the support module and disassemble ion pump power supply. Test and replace solid state switch as necessary.	
	H. Remove P7 from J7. Place a jumper wire from J7-A to J7-B. Measure the voltage from J7-X to J7-W. Voltage should be about 0.6 V dc if ion pump power supply is operational. If voltage is present proceed to Step I. If voltage is	The voltage present from Pin-X to Pin-W on J7 is due to the voltage drop across a diode and is present if the ion pump is drawing current. If this voltage is present but the panel meter shows no indication the monitoring circuit is probably malfunctioning. If voltage is

Troubleshooting Guide

Symptom	Action	Comments
5. Ion pump power supply inoperative (Cont)	H. (Cont) absent remove the support module from the instrument and remove the ion pump power supply from the support module. Use the ion pump power supply schematic to troubleshoot the problem.	absent either the power supply or the monitoring circuits within the power supply are probably inoperative.
	I. Use system wiring diagram to trace voltage path from P7 to the front panel meter.	
6. Analyzer power supply inoperative	A. Check M.S.P/S fuse on front panel. Should be 2A 3AG type.	
	B. Check ion pump current on front panel meter. Must be below 5 mA for for analyzer power supply to operate.	K4 must be energized by the vacuum control board for the analyzer power supply to turn on. This occurs when the ion pump current is less than 5 mA.
	C. Be sure P20 and J20 are mated securely.	
	D. Check V_{ACC} on front panel digital meter and electron accelerator and anode current on front panel test meter. If no voltages or currents are present proceed to Step E. If at least one of the currents or voltage is present proceed to Step G.	
	E. Remove P17 from J17 and measure the voltage from P17-B to P17-C. Should be 115 V ac. If voltage present proceed to Step G. If no voltage present proceed to Step F.	This is the ac supply to the analyzer power supply.

Troubleshooting Guide

Symptom	Action	Comments
6. Analyzer power supply inoperative (Cont)	F. Replace relay board 345097. If voltage still not present, replace vacuum control board 345100. If voltage still not present use system wiring diagram to trace voltage path from M.S.P/S switch to P7.	If replacing relay board cures problem, relay K4 is probably defective.
	G. Remove P19 from J19 and P20 from J20. Place jumper wires from P19-EE to J19-EE and from J20-CC to J20-DD. The following voltages should be present at J19. All are ±5%. From Pin / To Pin / Voltage J19-T / J20-S / +140 to +180 V dc J19-FF / J20-S / +135 to +165 V dc J19-DD / J20-S / +100 to +110 V dc J19-U / J20-S / +90 to +105 V dc J19-HH / J20-S / -20 to +5 V dc J19-LL / J20-S / -15 to 0 V dc J19-Z / J20-S / -15 to 2 V dc J19-W / J20-S / -12 to 5 V dc J19-CC / J20-S / -25 to -10 V dc J19-S / J20-S / -25 to -10 V dc J19-X / J19-EE / +90 to +240 V dc J19-Y / J19-EE / +190 to +205 V dc J19-JJ / J19-EE / +400 to +440 V dc J19-KK / J19-EE / +200 to +225 V dc	The voltages on Pins X, Y, JJ and KK are derived from high impedance sources and may be loaded down by the voltmeter used to measure them. Allowance should be made for circuit loading when anything other than a differential voltmeter is used. The data sheet supplied with each instrument lists the exact voltages required. Under NO circumstance should the analyzer power supply adjustments be tampered with.
	H. If one or more of the voltages are absent or incorrect the analyzer power supply will have to be removed and serviced. If voltages are present and correct proceed to Step I.	

Troubleshooting Guide

Symptom	Action	Comments
	I. Reconnect J19 and P19. Check P1 and P2 for secure mating with J1 and J2. Check filament continuity Fil #1 - P19 C to B should be less than 0.5 Ω. Fil #2 - P1 A to B should be less than 0.5 Ω. Place voltmeter from J20-D to J20-A. Jumper must be between J20-CC and J20-DD. If voltage is functional. Use system wiring diagram to trace current monitor signal to front panel meter. If voltage is not present proceed to Step J.	This voltage is proportional to the anode current (63 mV is equivalent to an anode current of 50 μA).
	J. Switch analyzer to alternate filament. See Section 2.6.	If switching to alternate filament cures problem one filament is probably defective.
7. Temperature controllers inoperative	A. Check front panel fuses. Should be 2A 3AG type. Check for overloads.	If the valve heater fuse is blown the source heater as well as the valve heater will be disabled because the valve temperature controller board has electronics that interface with the source temperature controller board.
	B. Check ion pump current. Must be below 5 mA for heaters to operate.	Relay K4 must be energized for heaters to operate.
	C. Check TS and TV positions of front panel digital meter. If meter reads 000 proceed to Step D. Normal operating range is 7.50 to 8.25 volts on both positions. If continued operation (as discussed in comments column to the right) fails to result in normal operation remove P5 from J5. Place a 1 KΩ (1/10 watt or larger) resistor from J5-H to J5-I. Measure the following voltages: From / To / Voltage J5-B / J5-A / 28 V ±4 V (source heater) J5-G / J5-F / 28 V ±4 V (valve heater)	Positions TS and TV give an indication of the state of the temperature controllers. Above 8.25 V the controller is providing full power to its associated heater. below 7.50 V it is completely turned off. After initial turn on approximately 20 minutes is required for the source temperature to stabilize and about 1 hour for the valve temperature. Prior to that the TS and TV readings will be much higher than 8.25 V. The degas mode raises both the valve and source temperature higher than normal. Returning to normal operation after degas causes both

Troubleshooting Guide

Symptom	Action	Comments
7. Temperature controllers inoperative (Cont)	C. (Cont) Under this configuration both heaters should be turned full on. If the voltage is not present replace the source temperature controller board 345098 or the valve temperature controller board 345099. If the voltages are correct measure the following resistances: From To Resistance P5-C P5-D 1.6 K - 100 KΩ P5-H P5-I 500 - 1.7 KΩ If the resistance is low check for shorts in the wiring. If the resistance is high check for an open circuit in the wiring. One of the temperature sensors may also be defective.	controllers to turn completely off until the temperatures return to normal. If the TS or TV voltages are very high or very low (but not zero) it may only be necessary to wait for the temperatures to stabilize.
	D. Measure the voltage from either side of the valve heater fuse to analyzer ground. Should be 28 V dc ±4 V. If voltage not present replace relay board 345097. If voltage still not present replace vacuum control board 345100. If still no voltage is present use system wiring diagram to trace voltage from the relay board to the fuse connection. If voltage is present replace valve temperature controller board 345099. If normal operation still is not achieved replace source temperature controller board 345098. If front panel test DVM still indicates 000 use system wiring diagram to trace test signals from J29 and J30 to the front panel test DVM	If replacing relay board cures problem, relay K4 is probably defective. As indicated in Comment 1 the valve temperature controller board has electronic circuits that interface with the source temperature controller board and a failure on the valve controller board may disable both circuits.

Troubleshooting Guide

Symptom	Action	Comments
8. ROUGH COMP light fails to light	A. Check TC position of front panel analog test meter. Analyzer pressure must be below 10 microns (2 μA on the 0-20 μA meter scale) for the light to indicate. If pressure is above 10 microns see Section 2.2 of Operational Procedures. If pressure is below 10 microns proceed to Step B.	If analyzer pressure is high the rough pumping procedure must be followed. The system should be checked for leaks and proper valve closings. If rough pumping fails to decrease TC reading proceed to Step E.
	B. Turn TC override switch to "ON". If light comes on replace vacuum control board 345100. If light does not light proceed to Step C.	
	C. Check the +24, +15 and -15 V positions of the front panel test DVM. Readings should be as listed in Table 2. If any voltage is incorrect proceed to Symptom No. 4. If voltages are correct proceed to Step D.	
	D. Replace relay board 345097. If light still fails to come on replace vacuum control board 345100. If light still is not lit use system wiring diagram to trace voltage path to light.	If replacing relay board cures problem relay K2 is probably defective.
	E. Check the +24, +15 and -15 V positions of the front panel test DVM. Readings should be as listed in Table 2-1. If any voltage is incorrect proceed to Symptom No. 4. If voltages are correct proceed to Step F.	
	F. Remove P9 from J9. Make following resistance tests: From — To — Resistance J9-C — J9-A — 18 Ω ±25% J9-C — J9-D — 9 Ω ±25% P9-C — P9-A — 1.0 k - 5.0 KΩ	

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Symptom	Action	Comments
8. ROUGH COMP light fails to light (Cont)	F. (Cont) If the resistances at J9 are out of specification the thermocouple is probably defective. If the resistance at P9 is incorrect proceed to Step G.	
	G. Using the system wiring diagram check for opens or shorts in the thermocouple wiring between P9 and the vacuum control board. If none are found replace the vacuum control board 345100.	
9. P_{AMB} reading on test DVM inaccurate	A. Check flow valves for proper conditions. Replace transducer amplifier 345110. If reading still incorrect proceed to Step B.	If sample pump is running and the sample valve is closed a partial vacuum will be built up in the sample flow lines and the P_{AMB} reading will be lower than normal.
	B. Remove P21 from J21. Measure the following resistances: From — To — Resistance J21-B — J21-C — 350 Ω ±20% J21-D — J21-A — 350 Ω ±20% If the resistance reading is out of specification replace the transducer.	A reading of twice the expected resistance indicates that one of the legs of the transducer bridge is open and the bridge will have to be replaced.
10. STANDBY light fails to come on	A. Check ion pump current. Must be less than 1 mA. M.S.P/S switch must be on. Measure voltage from terminal 9 of M.S.P/S switch to analyzer ground. Should be 28 V ±4V. If voltage is present proceed to Step C. Otherwise proceed to next step.	
	B. Replace relay board 345097. If voltage still is not present replace vacuum control board 345100. If voltage still missing use system wiring diagram to trace voltage path.	If replacing relay board cures problem K5 is probably defective.

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Symptom	Action	Comments
10. STANDBY light fails to come on (Cont)	C. Measure voltage across the lights in STANDBY switch. Should be 28 V ±4 V dc. If voltage not present replace relay K1. If voltage is present replace the lamps in the STANDBY switch.	
11. Analyzer fails to go into "ON" condition	A. Replace relay K1. If "ON" light still fails to come on measure voltage across lights in "ON" switch while pushing the button. Should be 28 V ±4 V dc. If voltage is present replace lights in "ON" switch.	
12. Test DVM does not indicate	A. If none of the digits of the test DVM are lit proceed to Step B. If test DVM reads 000 proceed to Step C. If voltage readings are unstable or inaccurate proceed to Step G.	
	B. Remove P11 from J11. Measure the following voltages: From / To / Voltage J11-H / J11-J / +5 V ±0.2 V dc J11-F / J11-G / +5 V ±0.2 V dc If both voltages are present, replace test DVM display board (345105) If both voltages are missing refer to Symptom No. 4 concerning loss of the +5 V dc supply. If only one voltage is absent use the system wiring diagram to trace the voltage path.	
	C. Set the test DVM selector switches to the +5 V position. Measure the voltage from terminal 29 to terminal 30 of the test selector board. Should be +5 V ±0.2 V dc. If the voltage is not present and no voltage appears in any of the test selector positions the test selector is probably defective. If the voltage is present proceed to the next step.	Terminals 29 and 30 are the last two terminals on the lower right side of the test selector board (as viewed from the panel front).

Symptom	Action	Comments
12. Test DVM does not indicate (Cont)	D. Remove P16 from J16. Measure the following voltages (with the test DVM selector switch set to the +5 V position): From / To / Voltage J16-A / J16-B / +5 V ±0.2 V dc J16-C / J16-D / +5 V ±0.2 V dc J16-E / J16-AC / +15 V ±0.5 V dc J16-F / J16-AC / -15 V ±0.5 V dc J16-y / J16-AC / +5 V ±0.2 V dc J16-w / J16-AC / -2 to +15 V dc J16-x / J16-AC / -2 to +15 V dc J16-z / J16-AC / -2 to +15 V dc J16-AA / J16-AC / -2 to +15 V dc J16-AB / J16-AC / -2 to +15 V dc	The voltage at Pin y is the voltage that the test DVM displays (with the appropriate scaling factor). Changing the test DVM selector switches should change this voltage.
	If any of the first five voltages is not present use the system wiring diagram to trace the voltage. If any of the other voltages are less than -2 volts or more than +15 volts use the system wiring diagram to trace the fault. If the voltages are present proceed to the next step.	The voltages at Pins w, x, y, z, AA and AB of J16 are the inputs to the multiplexer. If any of the voltages is out of the range specified in Step d the multiplexer may be damaged. The overvoltage condition should be corrected before replacing the multiplexer or A/D converter board.
	E. Reconnect P16 to J16. Check P15 and P11 to insure that they are mated properly with their respective connectors. If the test DVM still does not function properly replace the multiplexer board 345233 and the A/D converter board 345106. The display module must be disassembled to replace these boards.	
	F. If the test DVM still reads 000 replace the test DVM display board 345105.	

Symptom	Action	Comments
12. Test DVM does not indicate (Cont)	G. Push the "Display Test" button on the front panel. If any of the sections fail to light replace the test DVM display board 345105. If all sections light continue. Measure the voltage between terminals 29 and 30 of the test selector board as described in Step C. Check the +15 V, -15 V and +24 V positions of the test selector switches also (these voltages are scaled by a factor of 1/10). If any of these voltages is incorrect or unstable refer to Symptom 4. If the voltages are correct and stable proceed to the next step.	
	H. Follow procedures described in Steps D and E. If the test DVM is still malfunctioning replace the test DVM board 345105.	
13. Digital displays malfunctioning	A. Check front panel test DVM. If +5 V, +15 V, -15 V, or +24 V indications are incorrect proceed to Symptom 12, otherwise continue.	"FIL ON" light must be on for for digital display to operate. Refer to Symptom 11 if light will not come on.
	B. Disconnect P16 from J16. Measure the following voltages: From / To / Voltage / Function J16-w / J16-AC / -2 to +15 V dc / CO_2 J16-x / J16-AC / -2 to +15 V dc / F12 J16-z / J16-AC / -2 to +15 V dc / F11/114 J16-AA / J16-AC / -2 to +15 V dc / H_2 J16-AB / J16-AC / -2 to +15 V dc / O_2 If any of the voltages are out of range use the system wiring diagram to trace the fault. Otherwise proceed to the next step.	Any negative voltage will read 000 on the digital display. A voltage greater than +10 V may cause saturation in the digital circuitry and be displayed as a voltage lower than it actually is (but greater than +10 V).

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Symptom	Action	Comments
	C. Reconnect P16 to J16. If the CO_2, H_2 or O_2 channel does not display the approximate voltages as read in the previous step replace the multiplexer board 345233. If this does not cure the problem replace display channel board 345105 associated with that channel.	
14. Freon logic circuits malfunctioning	A. If the "UPDATE" light comes on when the "UPDATE" button is pushed proceed to Step C. Otherwise proceed to next step.	
	B. Remove the "UPDATE" light from its holder and check light for continuity. Replace if open. If light is good replace the Freon sequencer boards 345107 and 345217. If light still fails to work use Figures 3-2 and 3-3 to trace pushbutton and light wiring to card rack and check for continuity.	
	C. Push "ZERO CHECK" button on front panel. All the direct output voltages on the test DVM should drop to 0.00 -0.02 V. If all readings are correct proceed to Step I if operating in Freon 12/114 mode or Step K if in Freon 11/12 mode. Otherwise continue to next step.	
	D. Measure the voltage across the zero check pushbutton switch. Should be 28 V $\pm$4 V dc when the button is up and 0 V when button is pushed. If voltages are correct proceed to Step H. If voltage is not zero when button is pushed replace the switch, if 24 V supply is not present when button is not pushed proceed to next step.	

Troubleshooting Guide

Symptom	Action	Comments
14. Freon logic circuits malfunctioning (Cont)	E. Disconnect P18 from J18. Measure resistance from P18-D to P18-B. Should be an open circuit until zero check button is pushed. Then it should indicate less than one ohm. If not use the system wiring diagram to trace the fault. If correct proceed to next step.	
	F. Measure the resistance between J18-B and J18-E. Should be 25 Ω - 600 Ω. If resistance is not correct the Z-Axis relay or the parallel diode in the analyzer power supply is probably defective. The power supply must be removed for servicing. If resistance is correct proceed to next step.	This is the relay coil in parallel with a diode. The resistance will depend on the polarity of the ohmmeter and should be checked both ways.
	G. Measure the voltage between P18-E and P18-B. Do not turn on the M.S. P/S switch, just the L.V. P/S switch. Should be zero volts until the "ZERO CHECK" button is pushed, then should be 28 V $\pm$4 V dc. If voltage not present use Figures 3-2, 3-4, and 3-5 to trace voltage path. If voltage is correct reconnect P18 to J18 and proceed to next step.	
	H. Disconnect P20 from J20. Place a jumper from J20-CC to J20-DD. Measure the voltage from J20-X to J20-AA. Should be 200 V - 225 V dc. When the "ZERO CHECK" button is pushed this voltage should drop to zero. If not the analyzer power supply must be removed for servicing. See Figure 3-5. If voltage is correct use Figure 3-4 to trace voltage path to the analyzer.	

Troubleshooting Guide

Symptom	Action	Comments
14. Freon logic circuits malfunctioning (Cont)	I. Monitor V_{ACC} on the test DVM (normally 400 - 470 V dc). Turn scan switch (on analyzer power supply) to Freon position. Test DVM should read 295 V - 330 V dc. If voltage correct proceed to next step. If not the analyzer power supply must be removed for servicing.	
	J. Push the "UPDATE" button and monitor V_{ACC} on the test DVM. The voltage should drop to 200 - 330 V dc and remain that value for about 19 sec and then return to 400 - 470 V dc. If it does proceed to the next step. If it does not, replace the Freon logic sequencer boards 345107 and 345217. If this does not cure the problem use Figures 3-2, 3-3 and 3-4 to trace the scan relay control line and verify continuity.	There are three signal lines from the multiplexer to the Freon sequencer logic boards. They are connected as follows: Name — Connects To Start cycle — J38-13 Eight — J38-15 Advance — J37-18 If replacing the Freon logic boards fails to cure the problem Figures 3-2 and 3-3 should be used to trace these signal lines back to the multiplexer and verify continuity. If continuity is established but the logic circuits still fail to function replace the multiplexer board
	K. Push the "UPDATE" button and monitor the direct electrometer reading No. 3 (N_2). It should fall to zero and remain there for about 8 seconds before returning to its previous value. In the Freon 12/114 mode this cycle is repeated again after about 8 seconds. If this function is operating proceed to next step. If not, replace the Freon logic sequencer boards 345107 and 345217.	
	L. If it is suspected that the logic circuits are not supplying either the auto-zero or the Freon 114 sample and hold signal replace the Freon sequencer logic boards 345107 and 345217.	See comment above.

Troubleshooting Guide

Symptom	Action	Comments
15. Outputs out of tolerance	A. Check V_{ACC} to see that it agrees with the value set for the instrument. If not, go to Symptom 6. B. If one or more of the Freon channels are the only out of tolerance channels, go to Symptom 14 before proceeding with the following steps. If correction is not found return to Step G.	An out of tolerance condition should only be determined to exist based upon a calibration verification (see Section 2.4). Check all power supply voltages, and be sure that all controls are in their correct operating positions before proceeding with this procedure. Also check the DISPLAY CHECK to be sure that all displays are O.K. Steps C through F should be followed if all of the outputs appear to be off in the same direction. If one output is high or low and the others are correct or off in opposite direction, go to Step G.
	C. Check the ion pump pressure on the I_{IP} (200 μA) scale of the analog test meter. If it is more than $\pm$10% off from its last set point, Reset the variable inlet leak valve and recheck the outputs.	The internal pressure can normally vary from $\pm$20% to $\pm$50% without appreciably affecting the outputs, the exact value depending upon the sensitivity of a particular instrument. Over a long period of time the ion pump current will slowly rise even though the ion source pressure remains constant. Allowance for this should be made. The gain of the ratio circuit can be used as an indication of extent to which that is occurring. See Action Step D.
	D. Turn the digital test meter to the first position to the right of the TS position. This position is unmarked but the voltage indicated on the digital test meter is representative of the gain of the ratio circuit. Compare this number to previously recorded values. If it is significantly different the gain may be out of its active range. If the gain is at its maximum all of the outputs should be low. If the gain appears to be normal, go to Step F.	The gain output should be capable of ranging over a range of approximately a factor of two. The range is indicated in manufacturer's supplied data for this instrument. Typically, if an instrument is operating out of tolerance it will be due to low ion current outputs which will force the gain to its maximum value.

F

Troubleshooting Guide

Symptom	Action	Comments
15. Outputs out of tolerance (Cont)	E. Check I_{AN} on the analog test meter. If appreciably off from its set value, check the I_{EA}. If it is in the same direction, reset with the I EMIS potentiometer. If there is insufficient adjustment range turn the I_{AN} current to zero and switch to the other filament using the FIL switch. Turn the I_{AN} back up with I EMIS and reset. Then recheck operation. If the operation is still out of tolerance proceed to the next step.	If the I_{EA} is off significantly from its normal value it may indicate that the gun is out of tune. In this case proceed directly to the second filament as indicated in Step E.
	If the second filament will not tune properly, it indicates a problem in the analyzer power supply or the analyzer itself. Refer to Step 6 for possible corrective action on the power supply. Otherwise factory level maintenance is required.	If both filaments exhibit insufficient drive it may be due to the build up of a contact resistance on the J1 and J2 connectors Turn OFF the M.S. P/S and HEATERS and disconnect J1 and J2. Carefully clean Pins 1 and 8 on P1 and 4 and 5 on P2 with a craytex rubber abrasive stick (fine grade). Be careful not to bend the pins. Reconnect, power up, and check operation.
	F. Check the P_{AMB} indicator against another pressure gauge when the inlet system is sampling air at the normal flow rate. If it is off significantly go to Symptom 9.	If the pressure transducer or associated circuitry is malfunctioning the outputs will appear to be abnormally high or low. This condition will only be apparent when sampling ambient atmosphere because the inlet pressure is arbitrarily set when sampling a test gas mixture.
	G. If all the outputs are off in the same direction power down the system and replace the summing printed circuit card (345113). Turn on the system and recheck on a calibration gas mixture. If the problem is substantially corrected, but the outputs are still off in the same direction they may be brought into better agreement by adjusting the top potentiometer on the summing card. Adjust the pot and watch the O_2 output until it reads correct. Then check the other outputs.	The summing card is the third card counting from the left in the card rack adjacent to the analyzer power supply module. CAUTION: This pot should be adjusted only as a last resort after all other attempts to correct the problem have been tried.

Troubleshooting Guide

Symptom	Action	Comments
15. Outputs out of tolerance (Cont)	H. Depress the ZERO CHECK button and check the direct electrometer outputs with digital test meter (positions 1 through 7). They should all read 0.1 or 0.2 with the possible exception of the H_2 channel which may be higher. If okay, go to Step K. A reading of 00.0 is not acceptable on any channel that is reading low because it may indicate a negative zero offset. If a bad reading is observed remove the electrometer housing cover and attempt to adjust the zero pot on the appropriate electrometer card (see Figure 1-14). If successful, replace the desicant bags and replace the cover. Then recheck operation. If the zero cannot be reset go to Step I.	If the H_2 channel is off and it is necessary to obtain a true zero for this channel, turn the I EMIS pot to zero. There are only two pots on each electrometer. Adjust the pot nearest the center of the circuit card. Turn CW to make the reading more (positive).
	I. Replace the electrometer with a spare and check operation. If in tolerance operation is achieved. Replace the desicant and the cover and resume operation.	The gain of a given electrometer is only matched to its spare within $\pm 10\%$. Therefore the replacement of a single electrometer may not give outputs that are in tolerance.
	J. If out of tolerance operation is still obtained, but the outputs appear to be in substantially better agreement. It will be necessary to replace the full set of electrometers, as well as the ratio electronics and Freon correction cards.	The latter are in the card rack next to the analyzer power supply module and are comprised of the second through the sixth cards counting from the left.

Troubleshooting Guide

Symptom	Action	Comments
15. Outputs out of tolerance (Cont)	K. Check the analyzer background partial pressures by closing the variable inlet leak valve. Wait 15 minutes and then record the outputs, including a Freon update. Particularly note the suspect channel. If its background is substantially out of line compared to the guideline given then degas the ion source and valve by placing the heater switch to DEGAS. Leave in degas for a minimum of 2 hours and then turn the switch back to the ON position. Wait approximately 30 minutes and then admit a calibration sample and recheck operation. * One of these systems, S/N 001, has an ion scatter correction circuit which will cause the F12 channel to read high when there is no input sample. It may read as high as 30 m torr or 80. Ignore this reading. L. Observe the direct output of each electrometer while set up under nominal test conditions on the calibration gas mixture. Set the P_{AMB} indicated pressure to agree with a previously run calibration verification. Then compare the direct electrometer outputs with values recorded for the previous calibration verification. If any of the electrometer readings disagree with earlier readings by an amount which would indicate they are the source of the problem then go to Step I.	As a guideline on backgrounds: H_2 $\leq$ 2.0 torr O_2 $\leq$ 1 torr CO_2 $\leq$ 2.0 torr F12* $\leq$ 10 m torr F11 $\leq$ 4 m torr F114 $\leq$ 10 m torr N_2 $\leq$ 1 torr H_2O $\leq$ 2.0 torr

Troubleshooting Guide

Symptom	Action	Comments
15. Outputs out of tolerance (Cont)	M. If none of the foregoing steps has resulted in corrective action then recheck all power supply voltages and controls, and if they are all good, power down the system and replace all of the electrometers and all of the ratio and correction circuitry. (The second through the sixth cards in the signal processing card rack.) Power up the system and recheck operation on a calibration gas.	This complete card replacement is intended to catch malfunctions in the ratio circuits. Fault isolation procedures to the card level are not provided because of the difficulty of recalibrating the system which would be required if a single board were replaced.
	N. Check to see that the ion beams are still centered in the ion current collectors. Turn the digital test meter to the V_{ACC} position and note the reading. Admit a cal gas sample and allow time to stabilize. Adjust the SCAN pot on the analyzer power supply module. Watch the V_{ACC} reading and turn slowly in the direction to make it decrease. Watch the outputs, particularly those that are low and see if they increase. If they do, attempt to find a V_{ACC} setting for which correct output readings are obtained. The Freon peaks are the narrowest and therefore their outputs should be watched closely. Observe the F12 electrometer output (Position 6) on the digital test meter. If the calibration gas contains F11 observe its electrometer output at Position 7. If the calibration gas contains F114, check its beam centering by turning the FREON STEP switch on the analyzer power supply from NOR to STEP and maximizing the F114 electrometer output (Position 7) by adjusting the STEP ADJ pot. Again observe the V_{ACC} reading before tweeking. After adjusting the STEP ADJ return to the NOR position on the FREON STEP switch. If these adjustments are not successful return to the original V_{ACC} readings.	Over a long period of time and under certain conditions it is possible that the analyzer magnet has lost some of its field strength This will cause the ion beams to move out of their collectors. Because the collectors are not perfectly aligned and have different widths some channels will be affected more than others.

Troubleshooting Guide

Symptom	Action	Comments
15. Outputs out of tolerance (Cont)	O. If none of the preceding action has corrected the out of tolerance condition the system will require service by the manufacturer.	

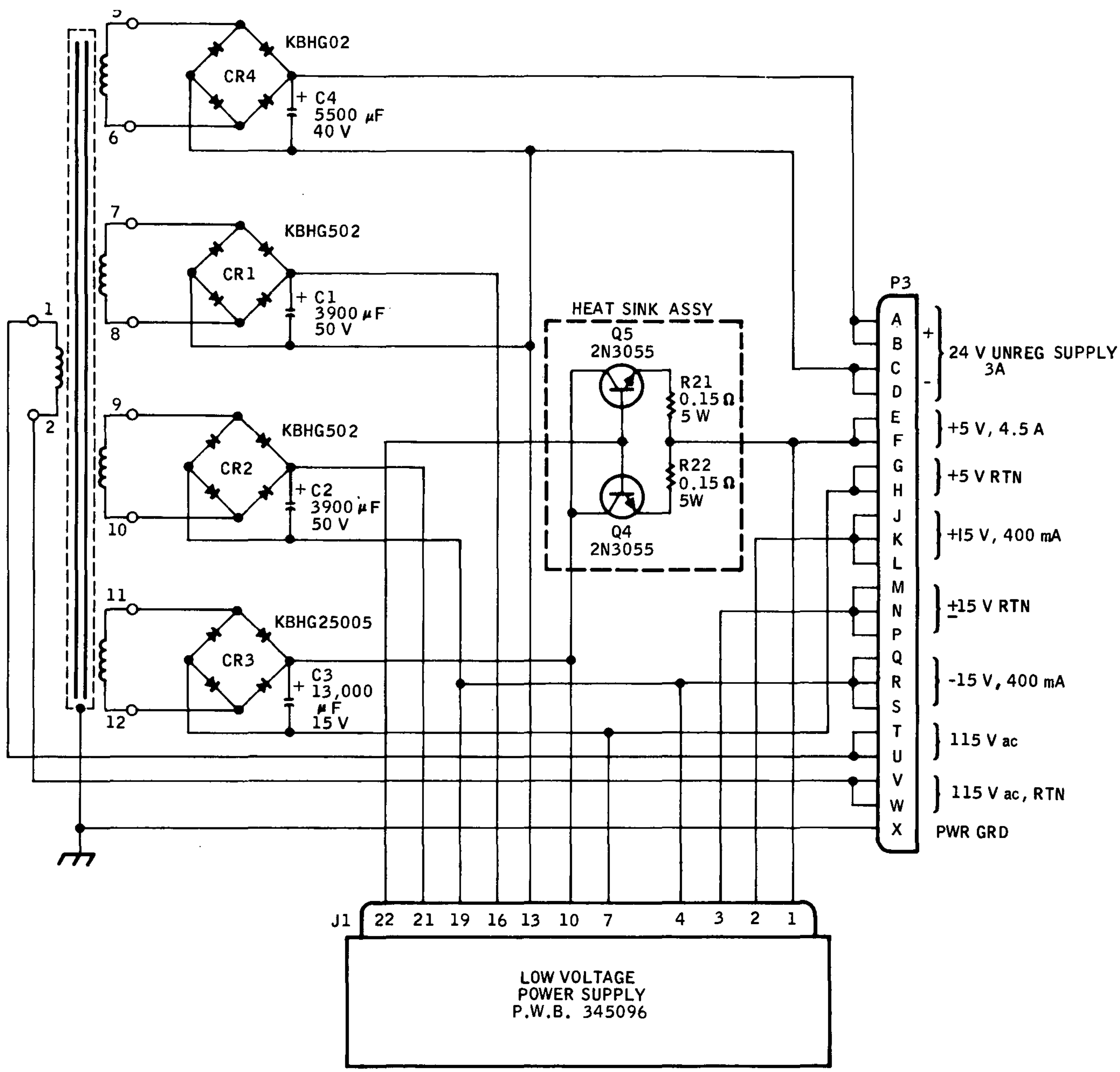

FIGURE 3-1
Low Voltage Power Supply Schematic

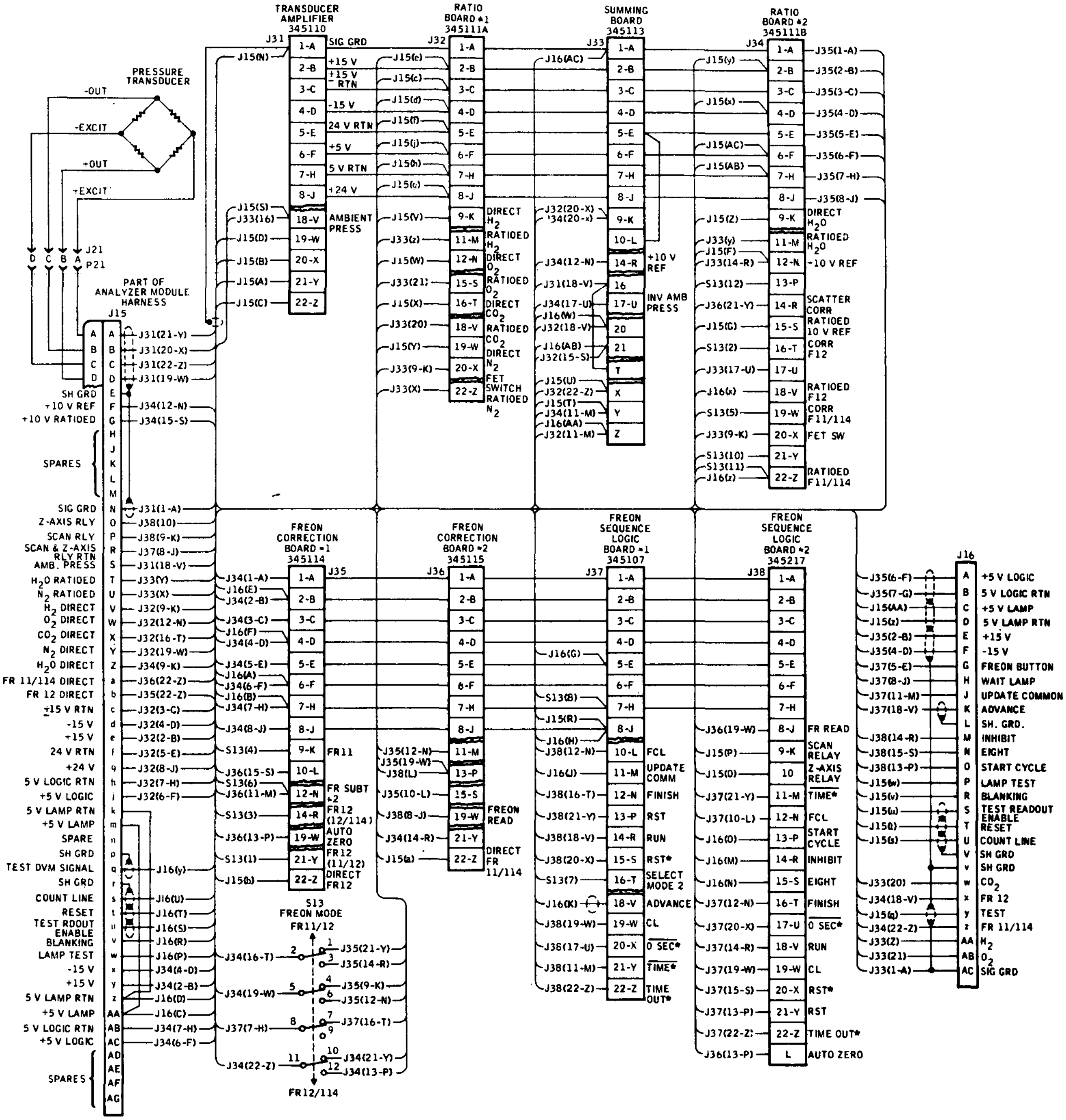

FIGURE 3-2
Card Rack Schematic

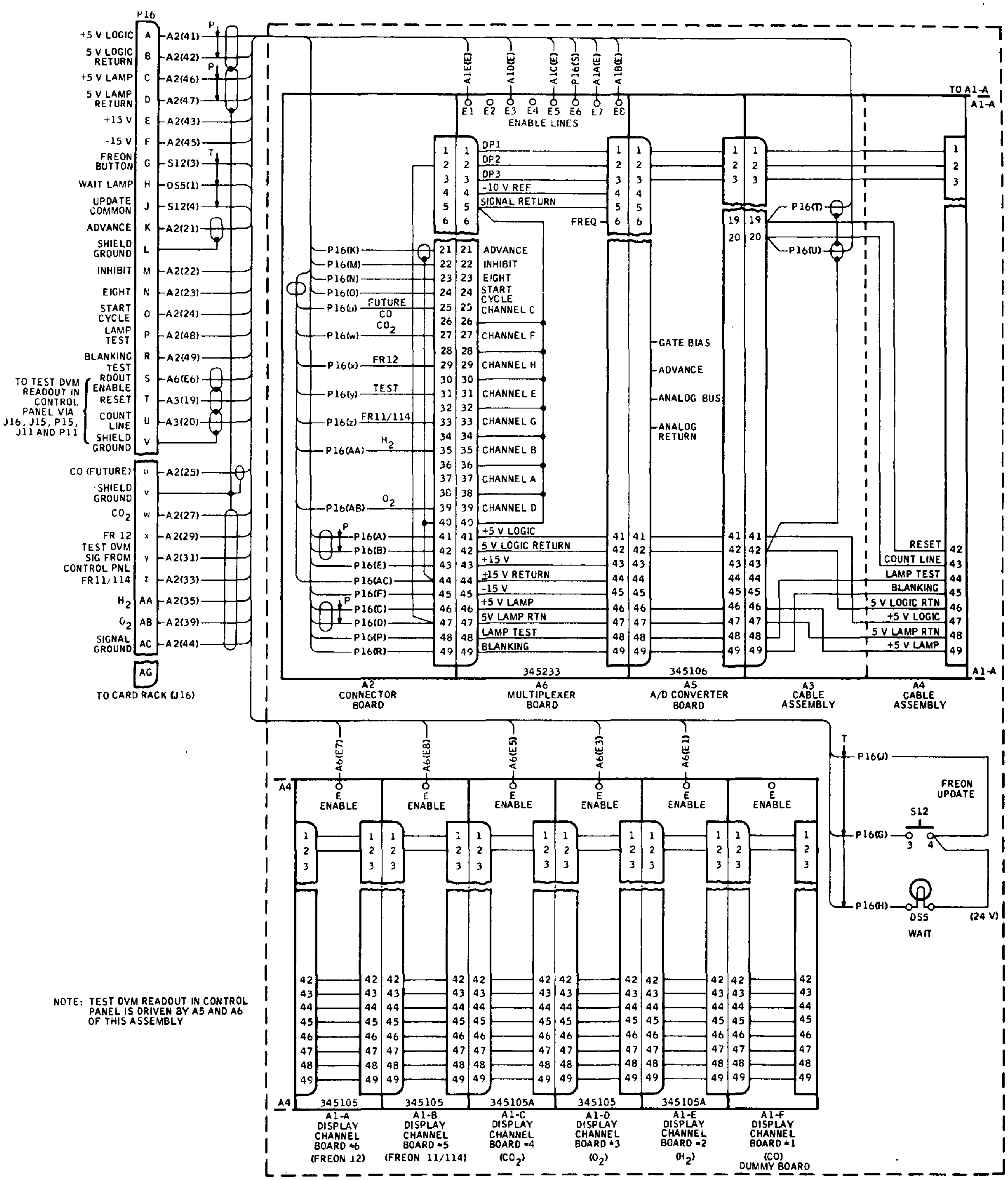

FIGURE 3-3
Readout Assembly Schematic

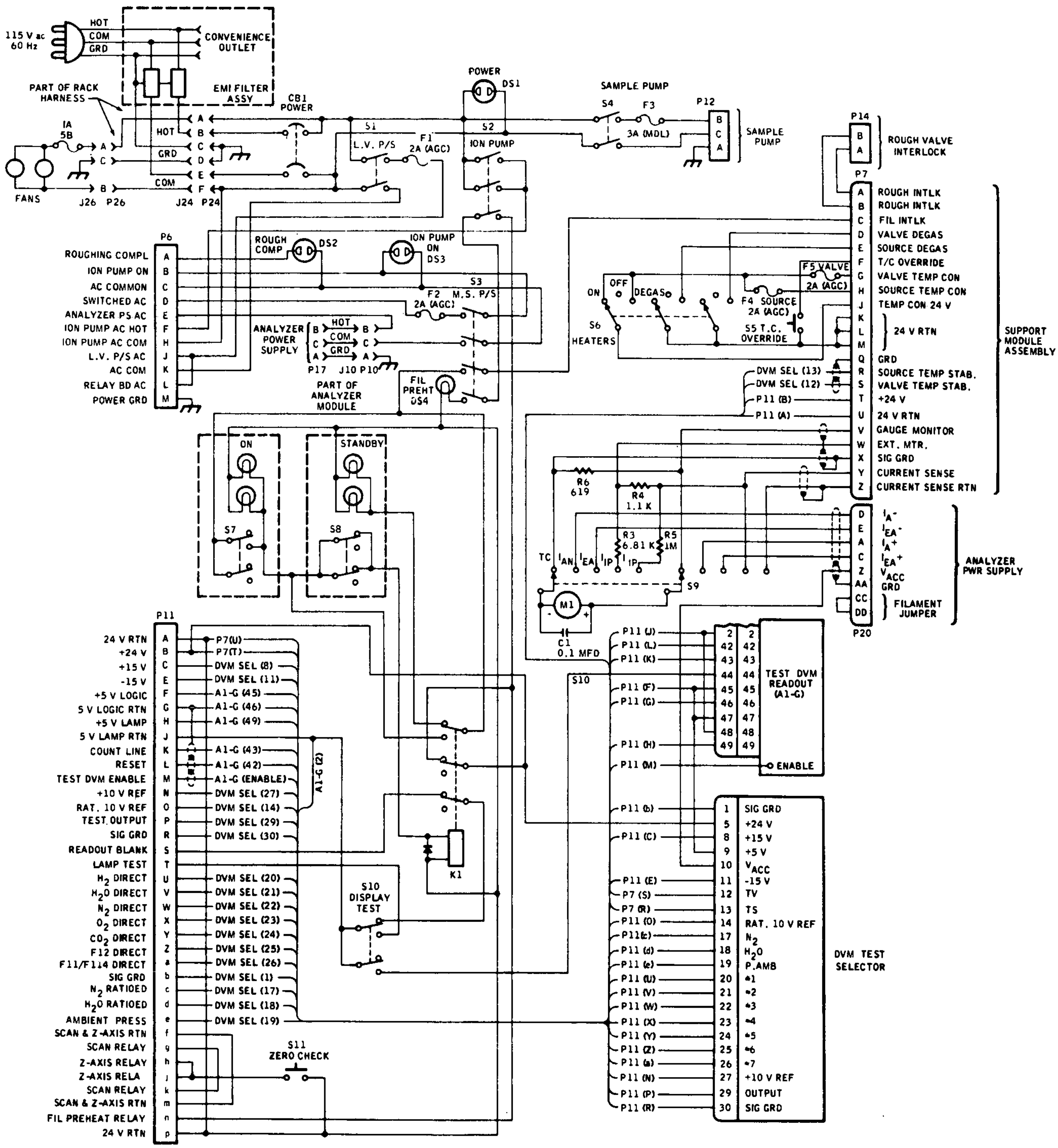

FIGURE 3-4
Control Panel Schematic

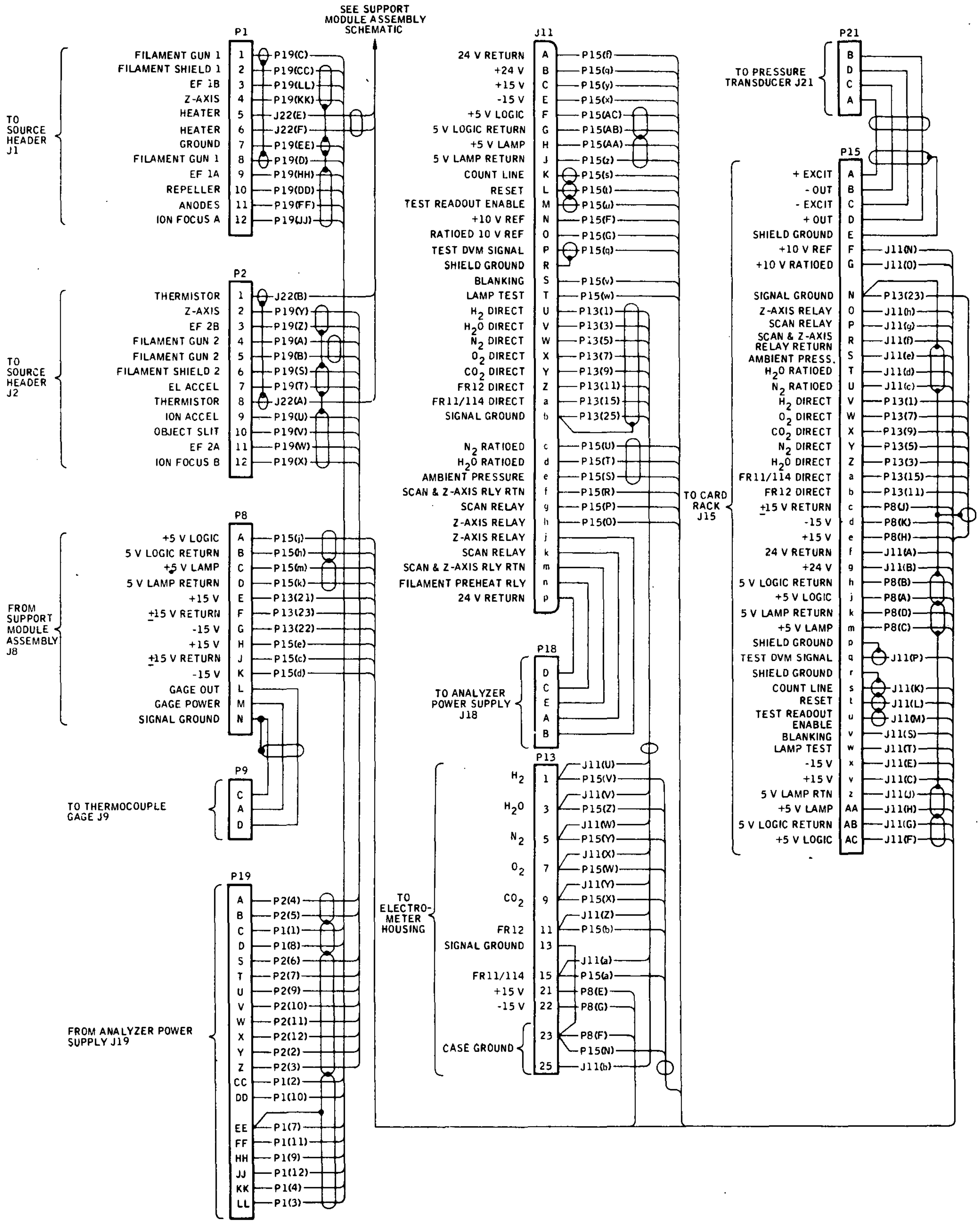

FIGURE 3-5
System Harness Schematic

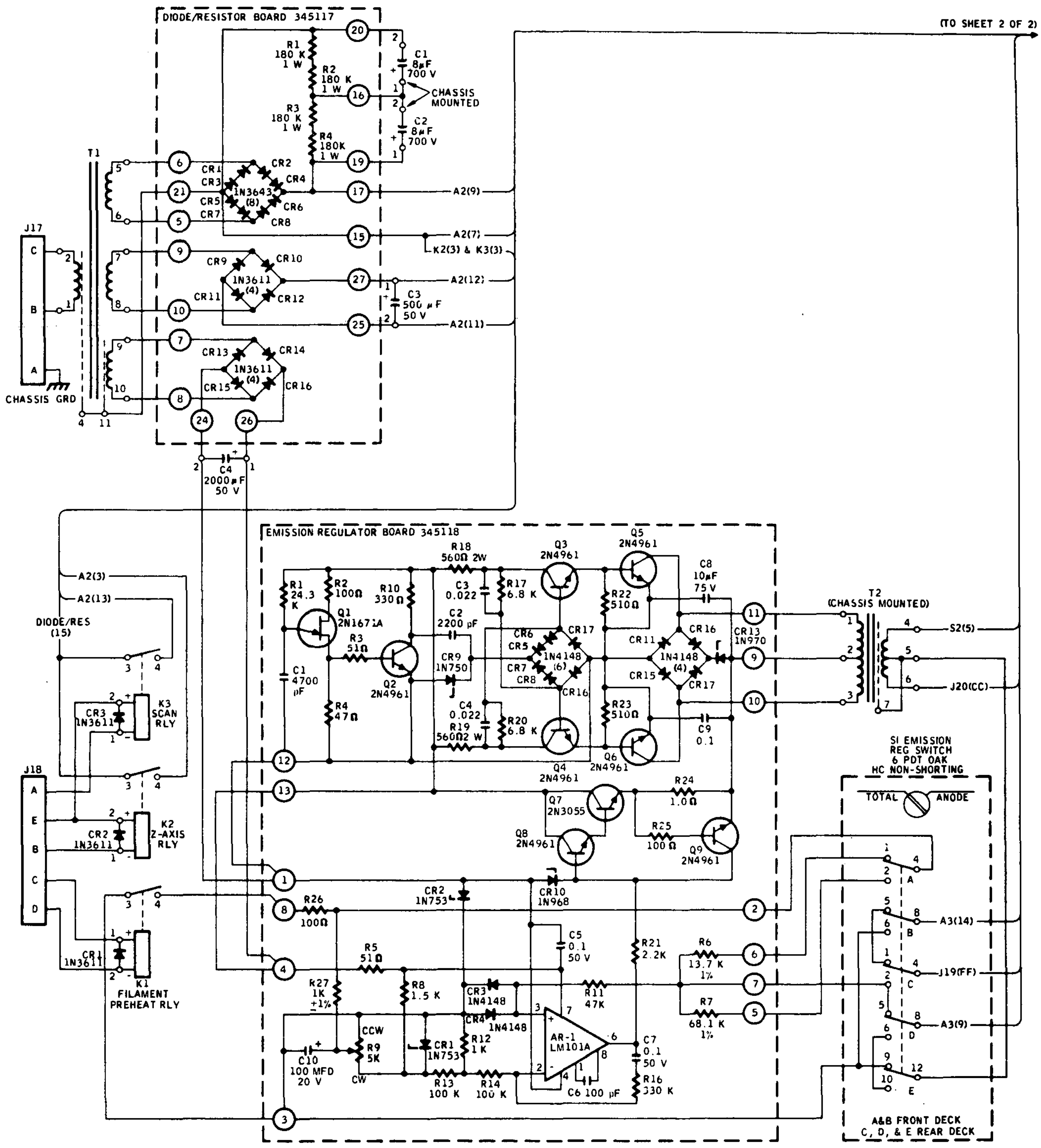

FIGURE 3-6
Analyzer Power Supply Schematic (Sheet 1 of 2)

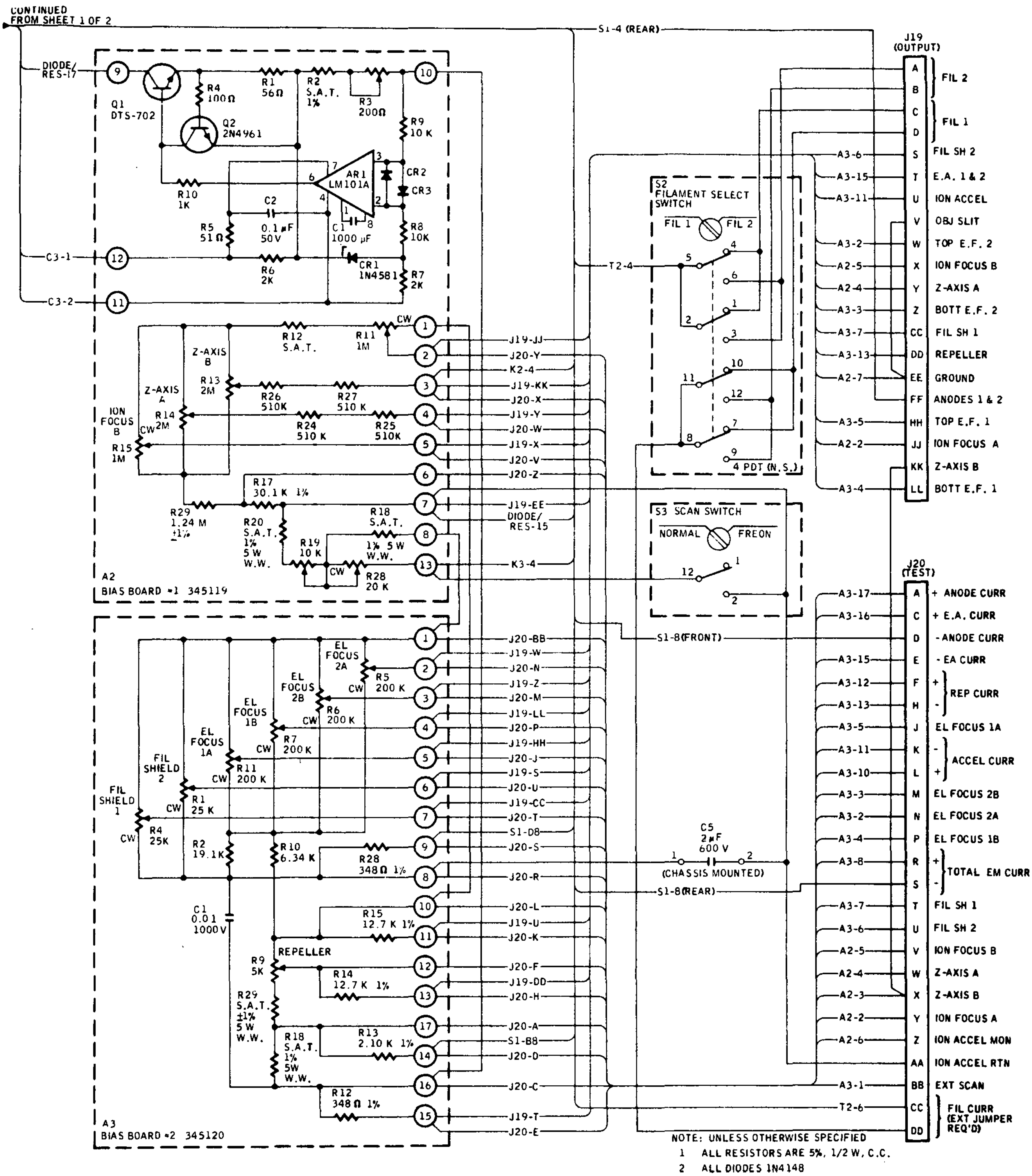

FIGURE 3-6
Analyzer Power Supply Schematic (Sheet 2 of 2)

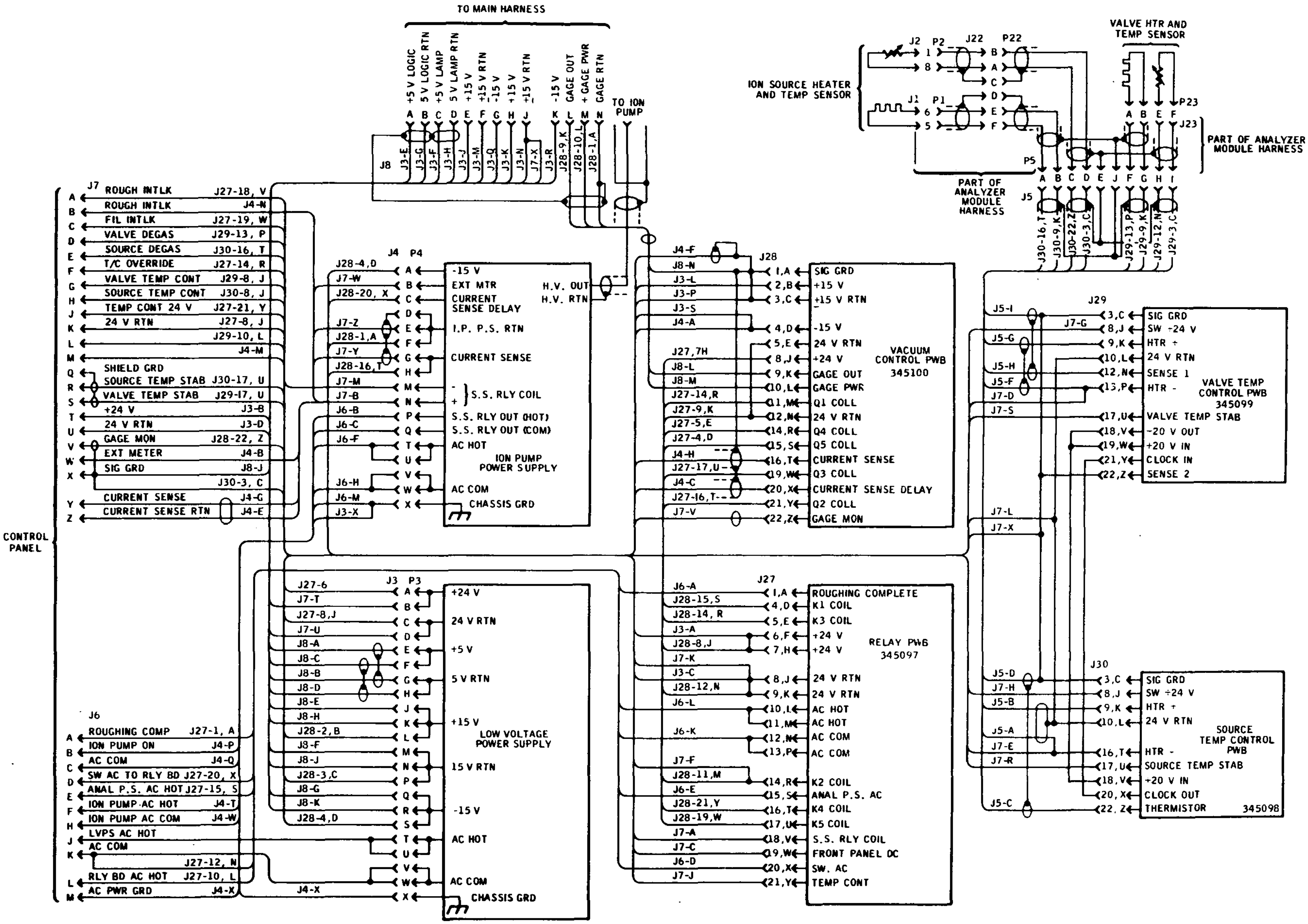

FIGURE 3-7
Support Module Assembly Schematic

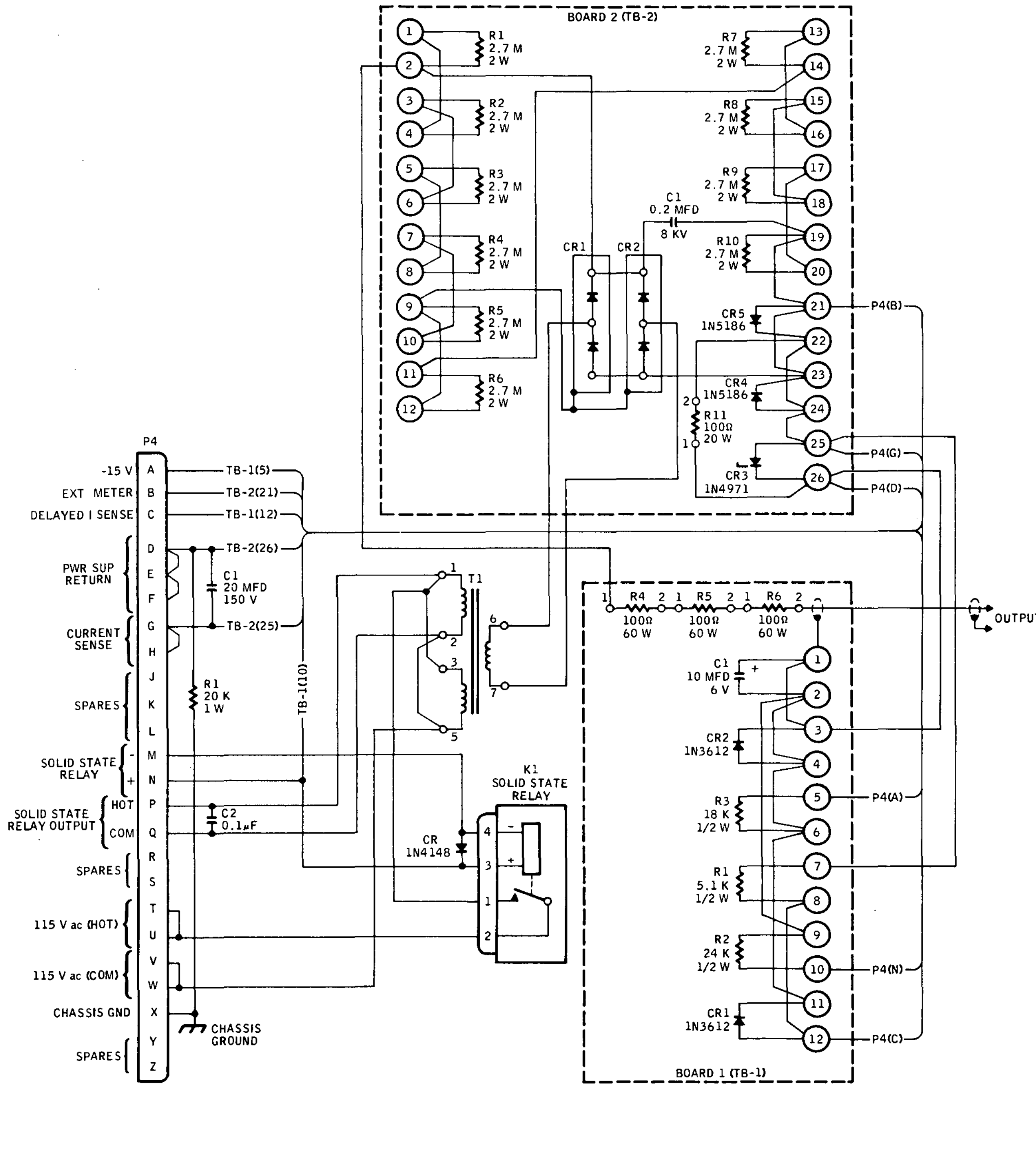

FIGURE 3-8
Ion Pump Power Supply Schematic

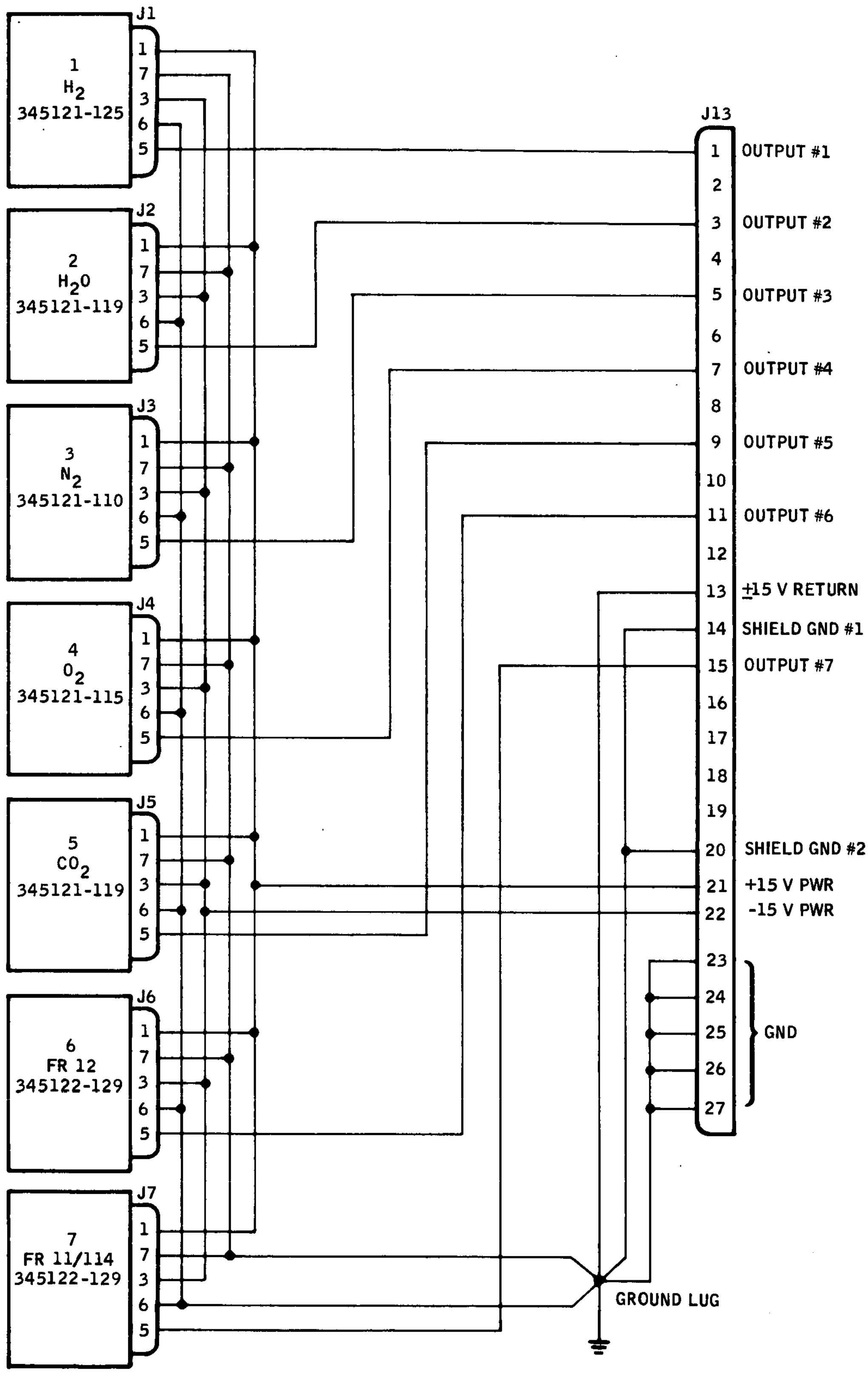

FIGURE 3-9
Electrometer Housing Schematic